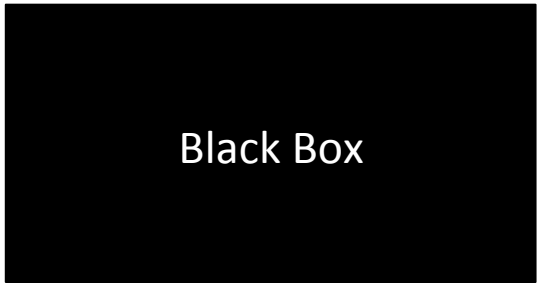
Final Review

Announcements

- Term Paper due next Tuesday
- Rubric and papers are posted
  - Choose only one to summarize
- Final on Monday at 11am



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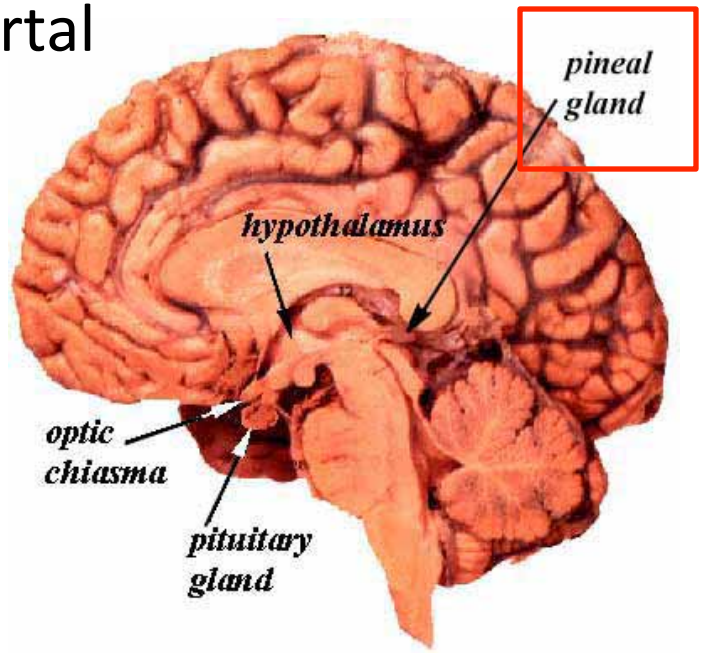
Cognitive Neuroscience

- Infer what is happening by looking at behavior
  - Behavioral paradigms
- Observe what happens when the box (the brain) is damaged
  - Case studies
- Observe what happens when we mess with the box
  - Brain stimulation
- Can image what is happening inside the box
  - Brain imaging

History: How is mind related to the brain?

- Mind-body problem: how can a physical substance give rise to our feelings, thoughts, emotions?
- Dualism - Rene Descartes (1596-1650)
  - Mind was non-physical (awareness) and immortal
  - Brain was physical and mortal
  - Interact in the…



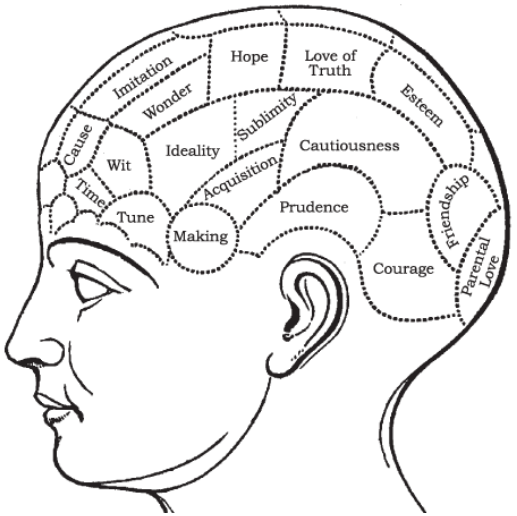
How is mind related to the brain?

- Dual-aspect theory (Spinoza)
  - Mind and brain are two aspects of the same thing (emergent properties)
  - Subjective and objective

- Reductionism (Churchland, Crick)
  - Mind can be reduced to biological constructs (e.g., patterns of neuronal firing, neurotransmitters)
  - "there is no soul, no mind, only the brain"
  - Only objective

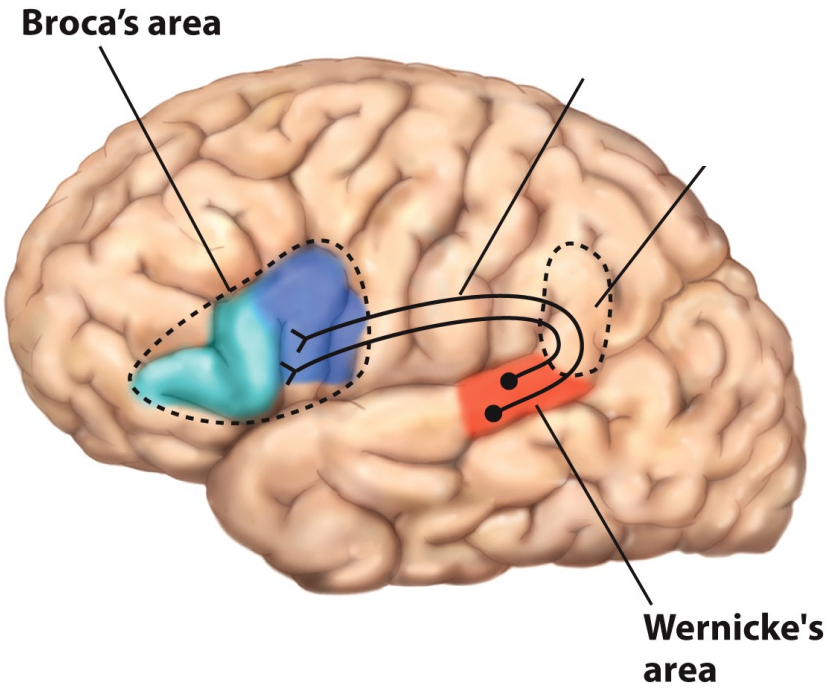
Phrenology (early 19th century)

- Led by Franz Gall
  (1758-1828)
- "Localizationist" view
  - *Cognitive* functions to specific brain regions
  - Idea:
    - Using a mental function caused corresponding brain region to grow bigger,
    - Which created bumps on skull



Localizationism (1860s)

- 1861: Paul Broca's patient "Tan"
  - Inability to generate speech *(Broca's aphasia)*
  - Post-mortem autopsy found left anterior region lesion
- 1874: Carl Wernicke
  - Comprehension loss *(Wernicke's aphasia)*
  - Post-mortem autopsy found left posterior region lesion



Localizationism vs Holism: Who wins?

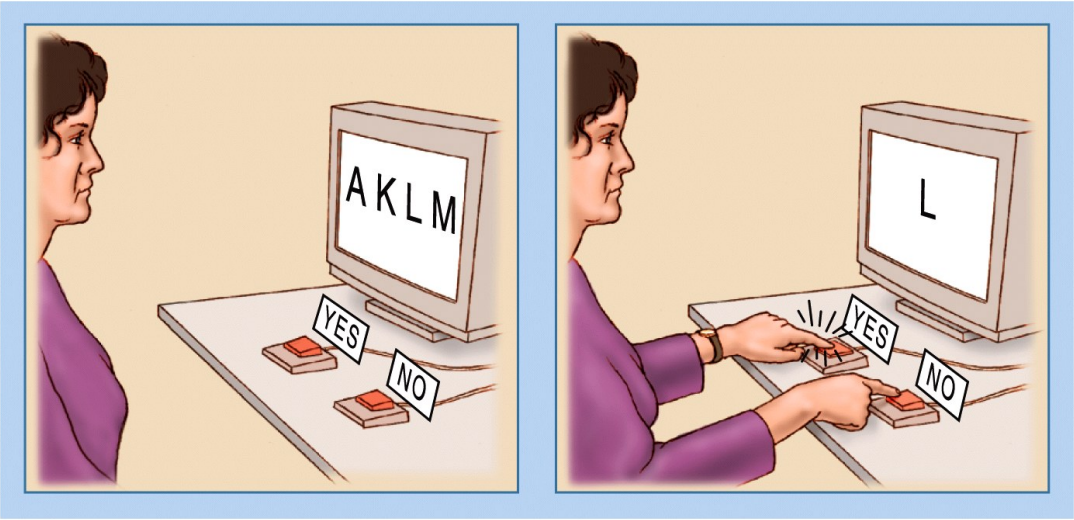
- Both were partially right

- Specific processes can be localized to single brain regions

- BUT complex functions are carried out by many brains regions acting in concert

- Debate continues in almost every domain of study in cognitive neuroscience.

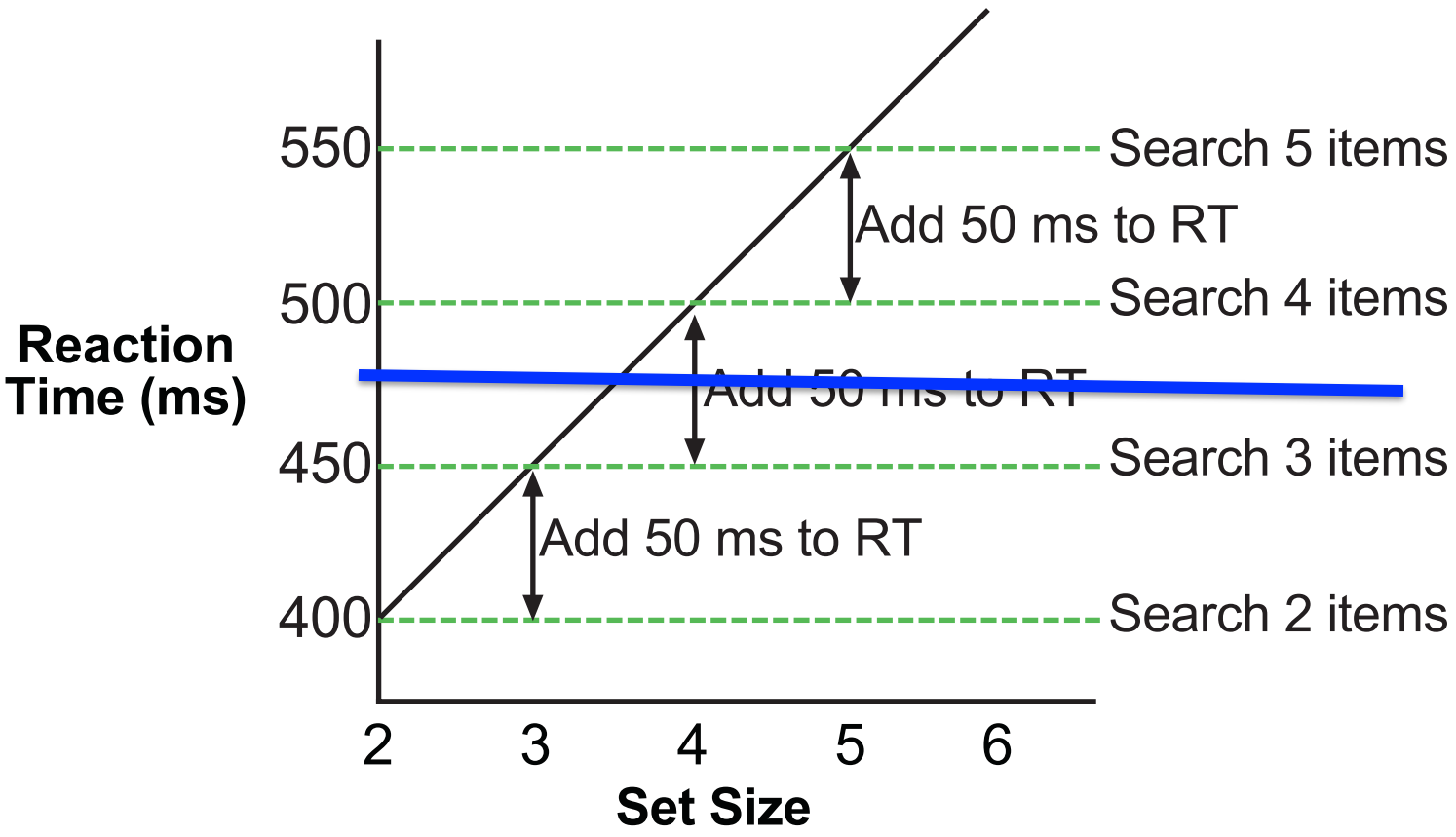
Behavioral paradigm example: Sternberg short-term memory experiment



- Subject sees letters on the screen and then has to decide if a letter came from the group.
-
-

Serial search: linear increase in RT

RT goes up by 50 ms for each item added to the array
(Slope = 50 ms/item).



Parallel search: flat RT function

Methods

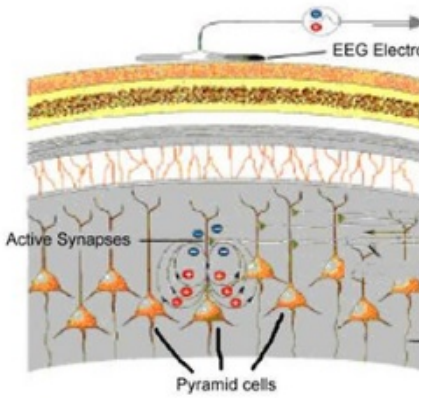
- Invasive – damage to scalp or brain
  - Deep brain stimulation
  - Single cell recording & brain lesions
- Non-invasive – no damage
  - tDCS and TMS
  - EEG and fMRI

Methods

- Direct – actually stimulating/measuring neuron activity
  - Deep brain stimulation
  - Single cell recording
- Indirect – stimulating/measuring brain activity at a larger scale
  - tDCS, TMS
  - fMRI, EEG

Imaging – correlation only

- *When* does a brain function occur?
  - EEG (high temporal resolution)

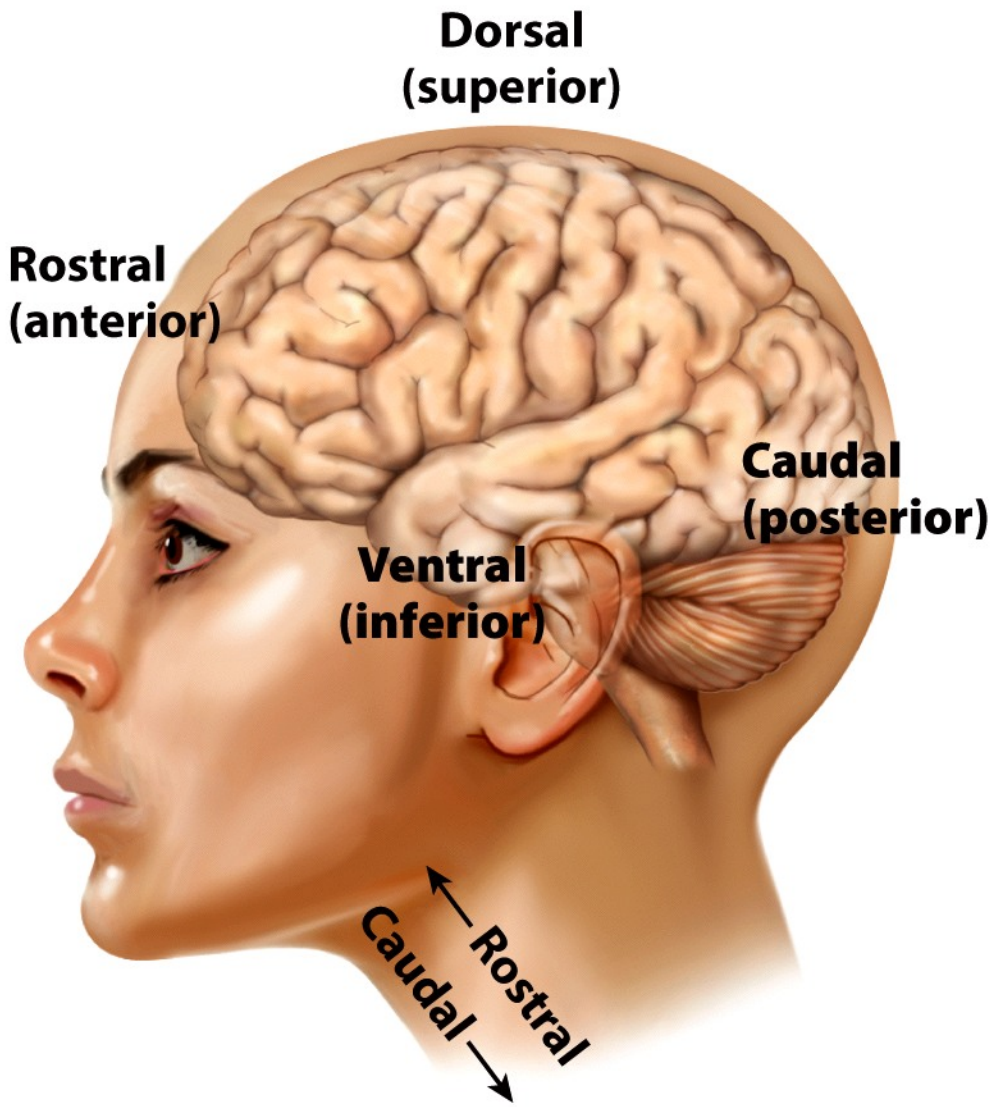


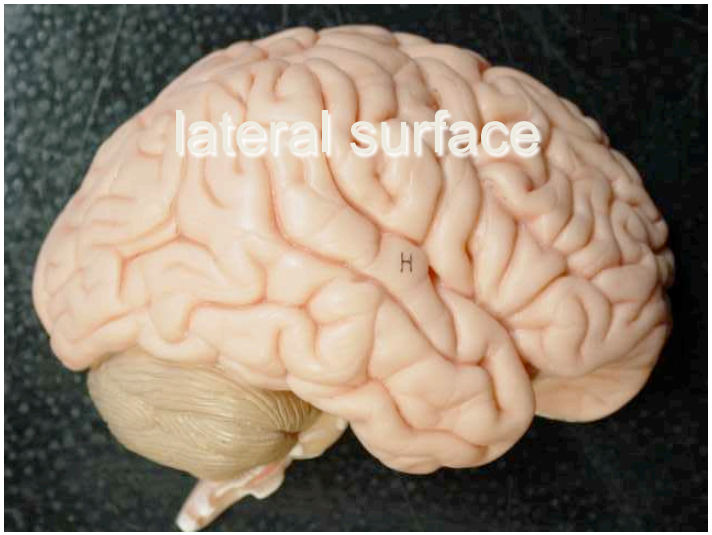
- *Where* in the brain is used for this function?
  - fMRI (high spatial resolution),

Lesions, brain stimulation, brain imaging of a brain area

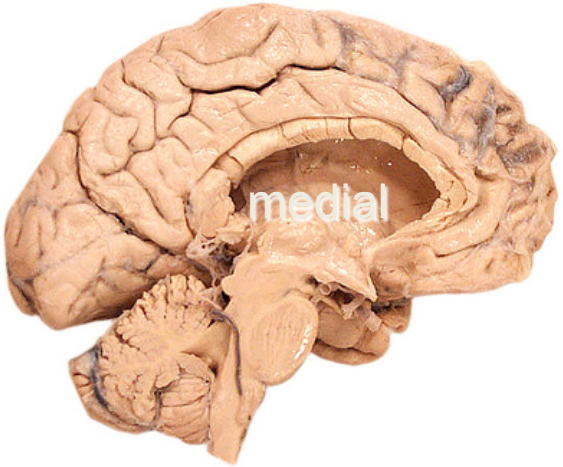
	Broca's area	Wernicke's area	
Speech Production	X	✓	Single dissociation
Speech Comprehension	✓	X	Single dissociation

Together – double dissociation

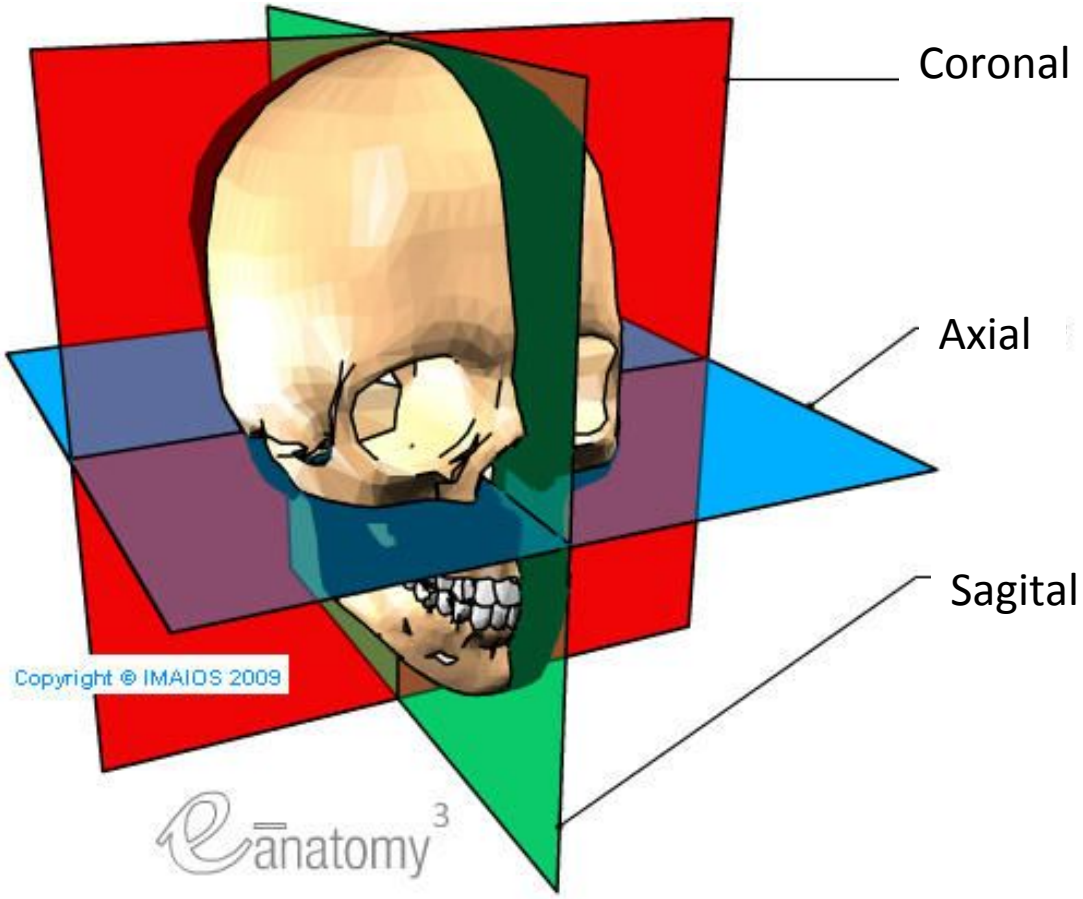

Dorsal
(superior)
Rostral
(anterior)
Caudal
(posterior)
Ventral
(inferior)
Rostral
Caudal



- Lateral: toward the outside.



- Medial: toward the inside (middle).



- Sagittal, coronal, and axial planes.

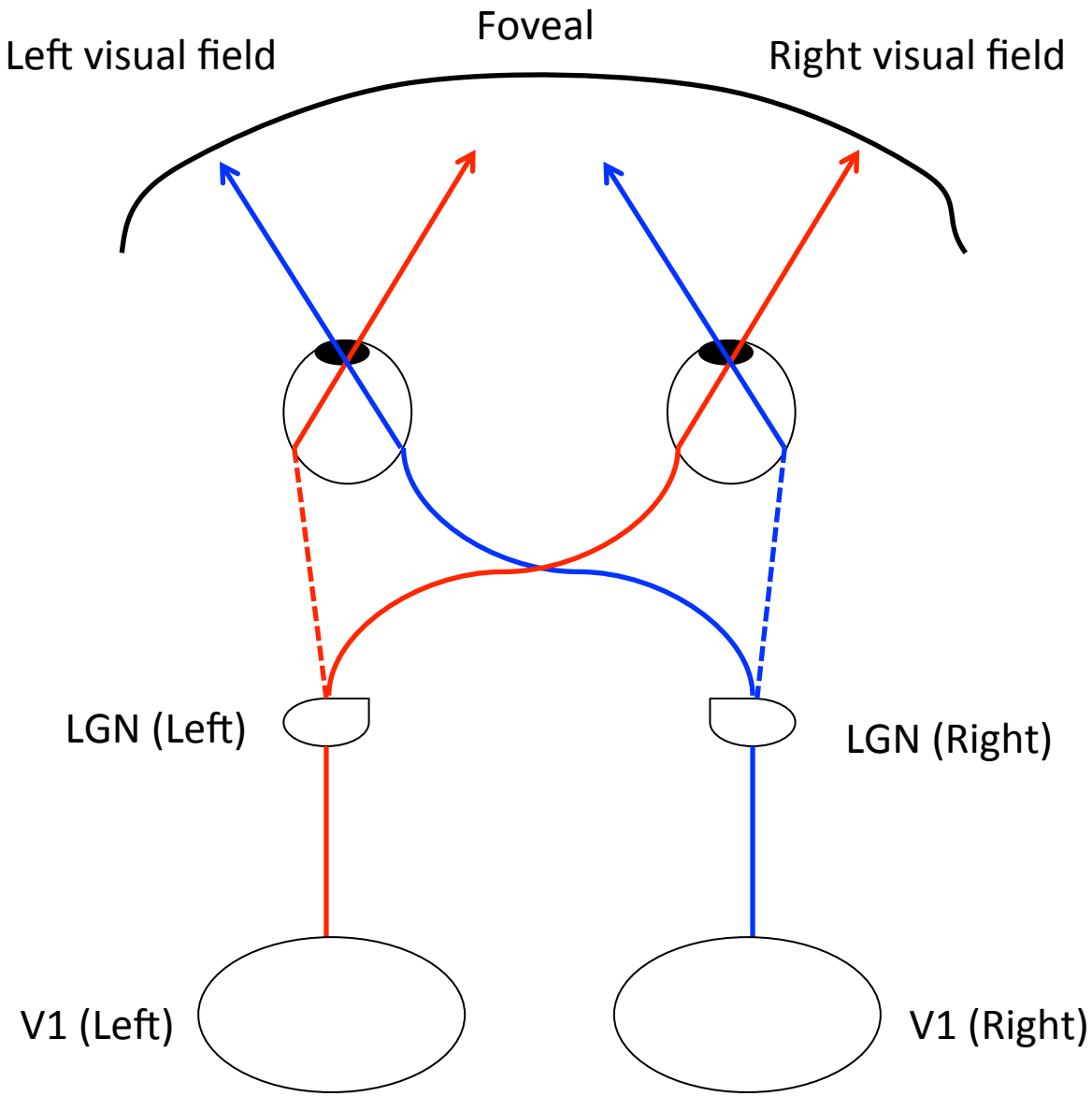
Functional neuroanatomy

- Broadman's area
  - Defined through histology
- Brain
  - Gray and white matter
  - Gyrus and sulcus
  - Lobes
  - Functional subdivision: e.g., within Frontal lobe
- Cortical maps: homunculus
  - Motor cortex and somatosensory cortex

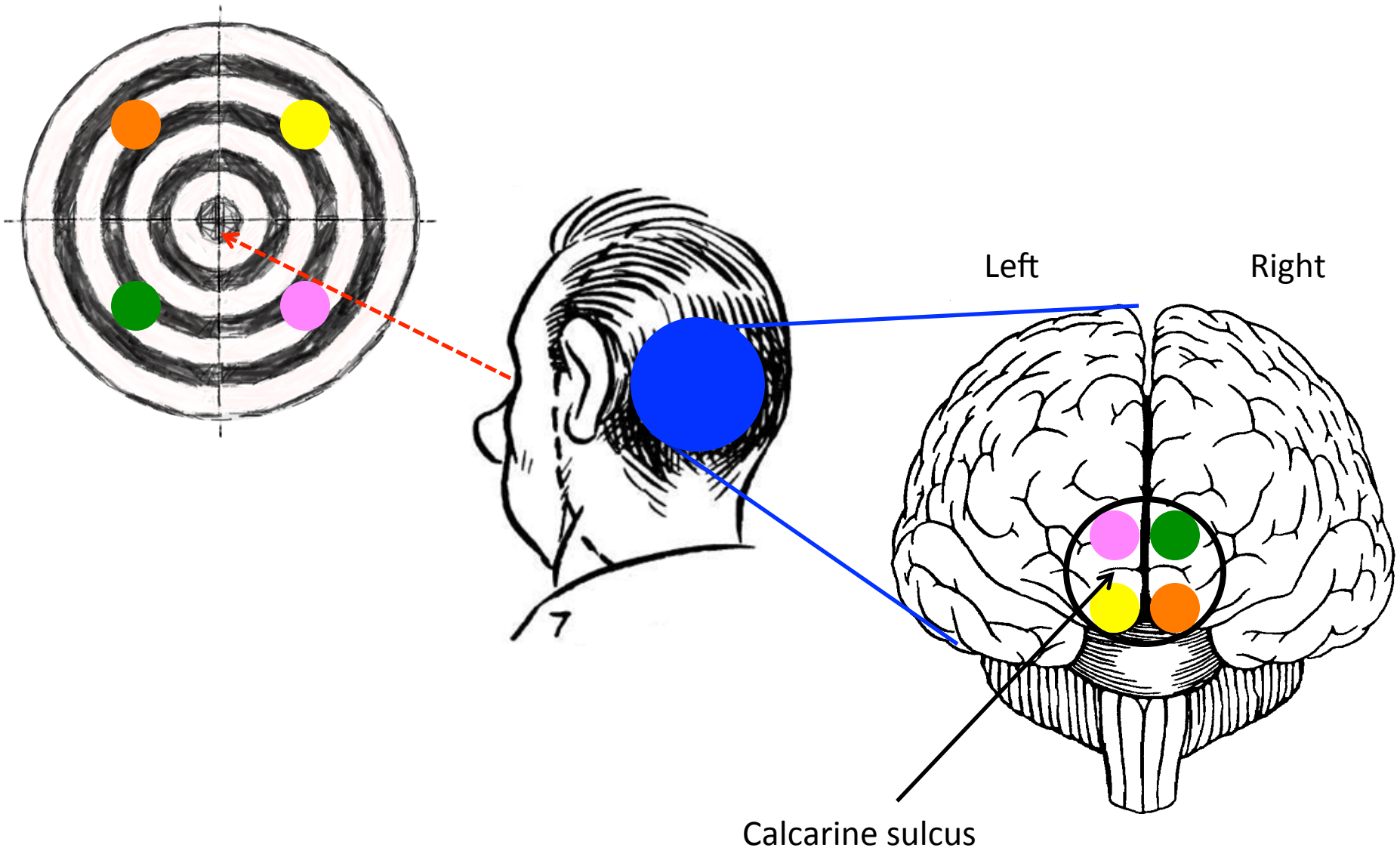
Essentials: Vision

- Vision
  - Visual hierarchy & pathway
  - what happens with damages to different parts of visual pathway.
- Vision ≠ Camcorder: Flexible mapping between external world and perception
  - Functional overrepresentation
  - Cortical plasticity
  - Perceptual filling-in

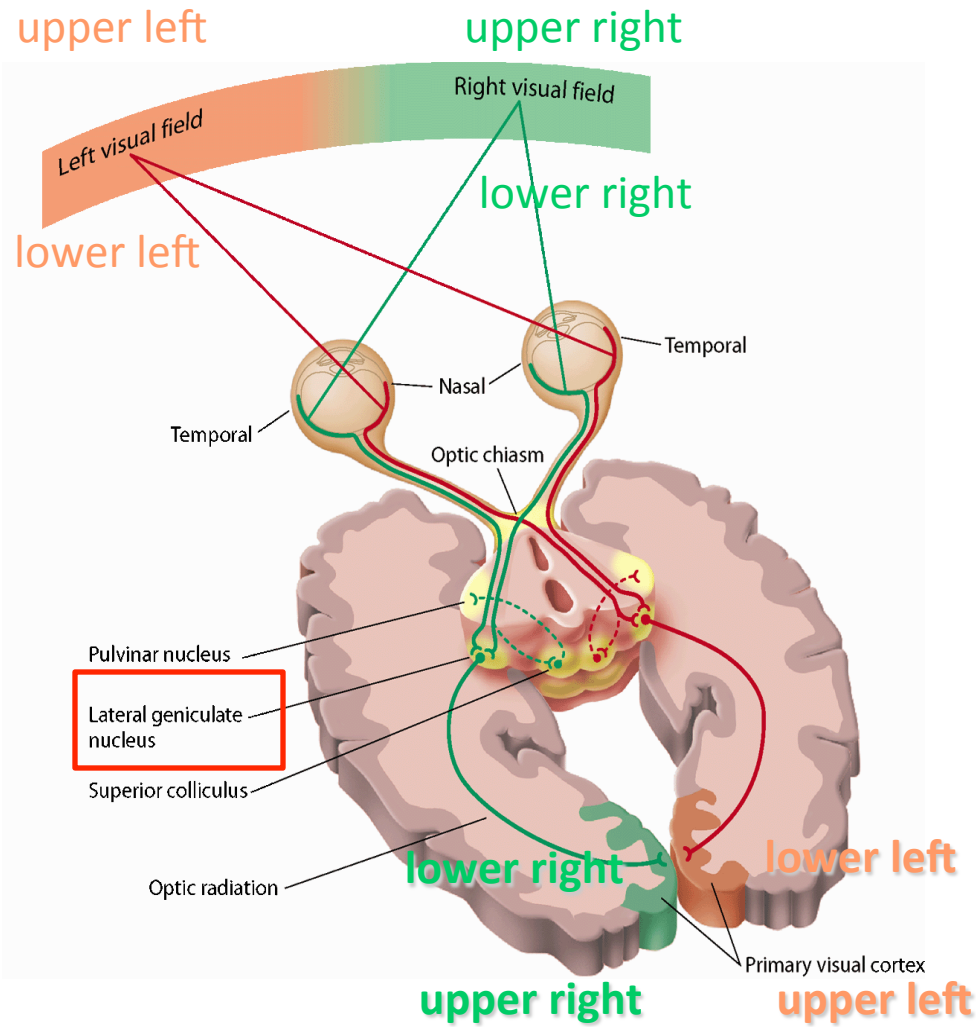
Visual pathway



Visual field and visual cortex

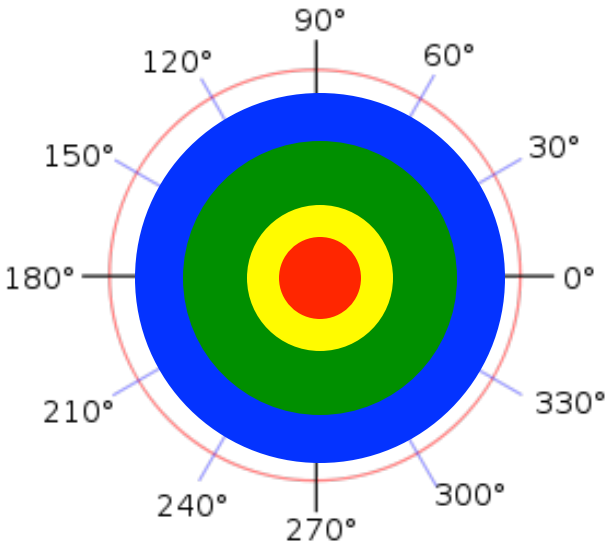


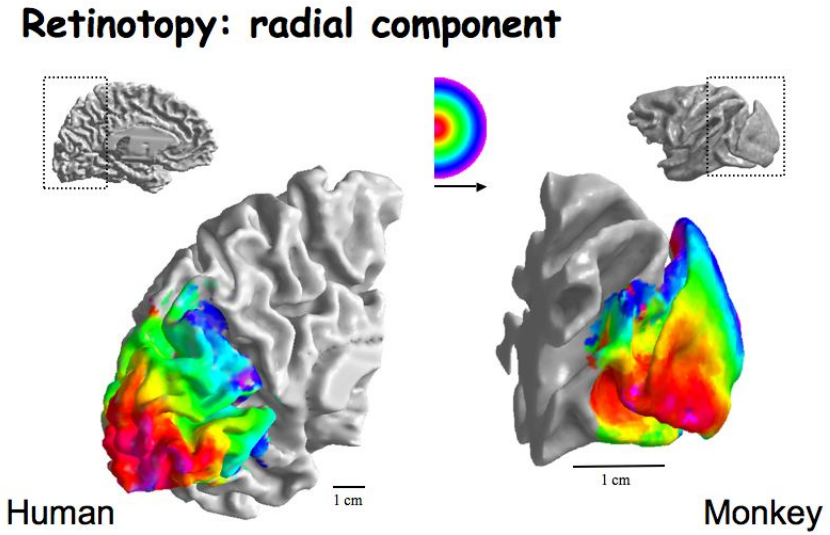
Inversion of visual world in cortex



Organization of visual cortex

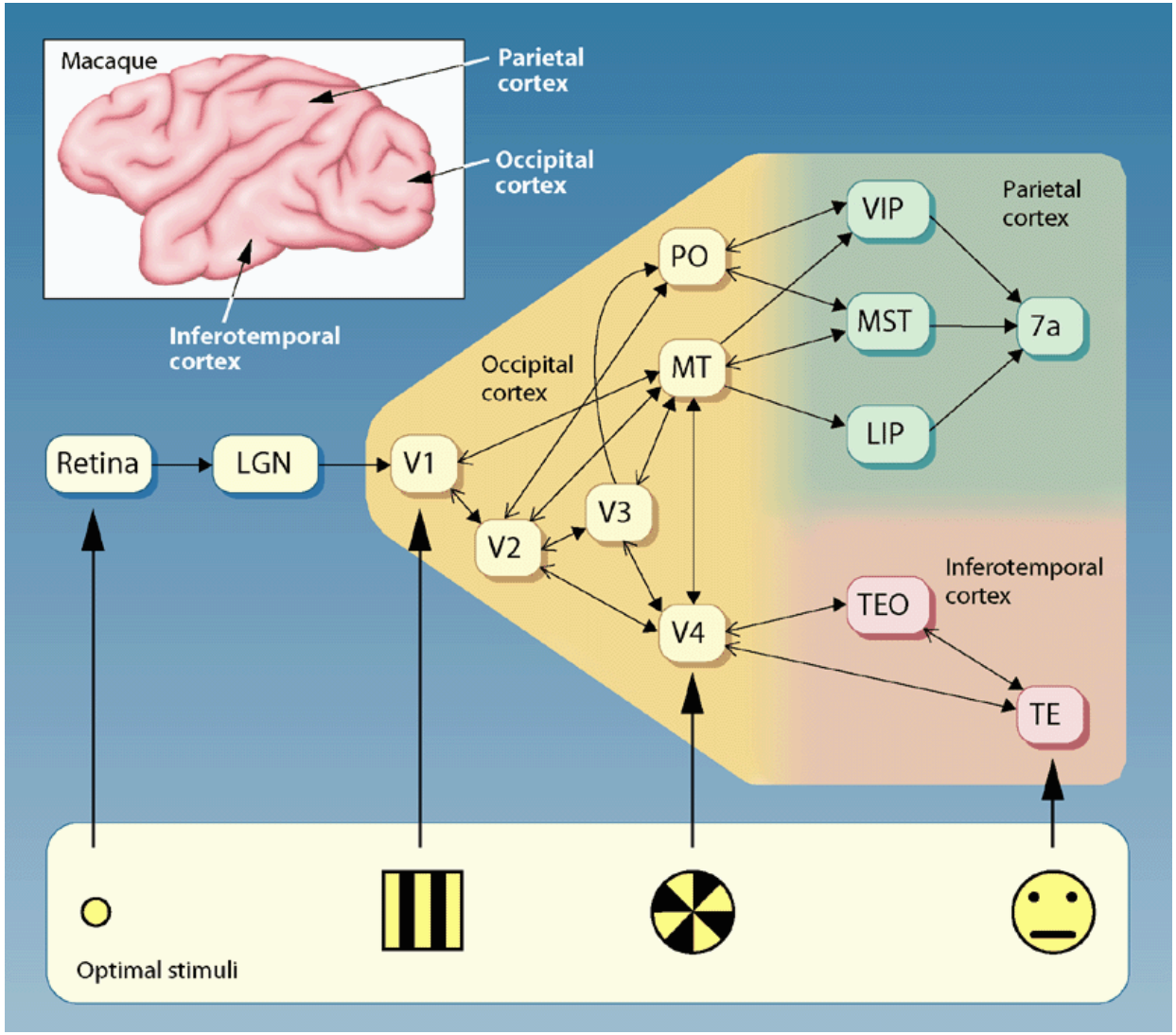
- topography of the visual world is preserved in V1~v4





http://www.cns.nyu.edu/~david/courses/perception/lecturenotes/what-where/what-where.html

Next stop: V4, MT, LOC

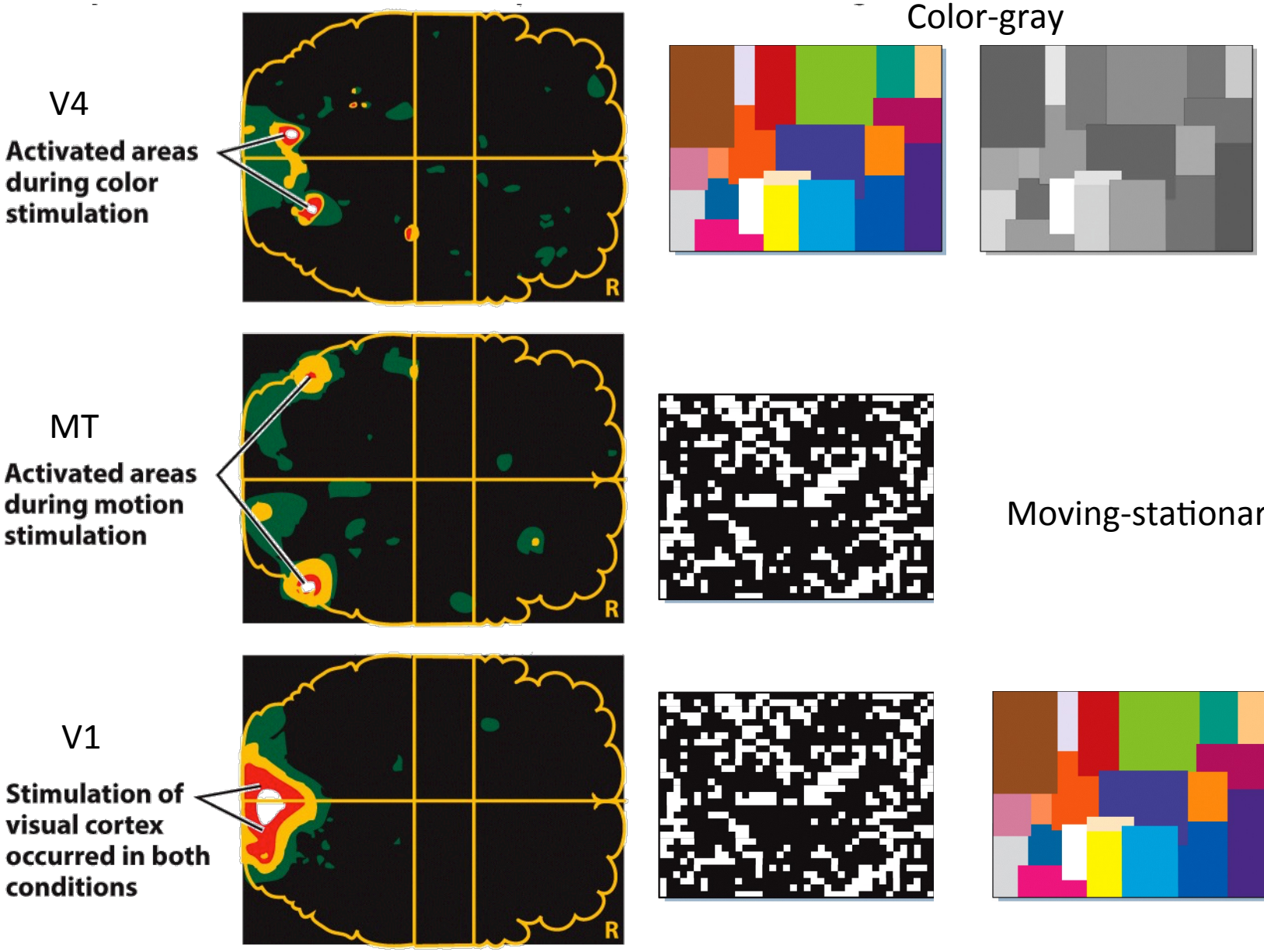


Dorsal pathway

Ventral pathway

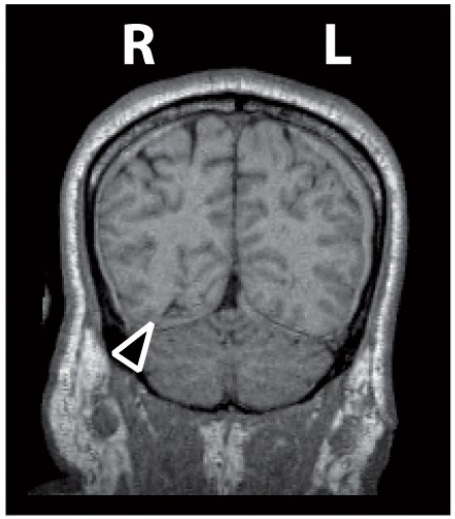
Van Essen and DeYoe 1995

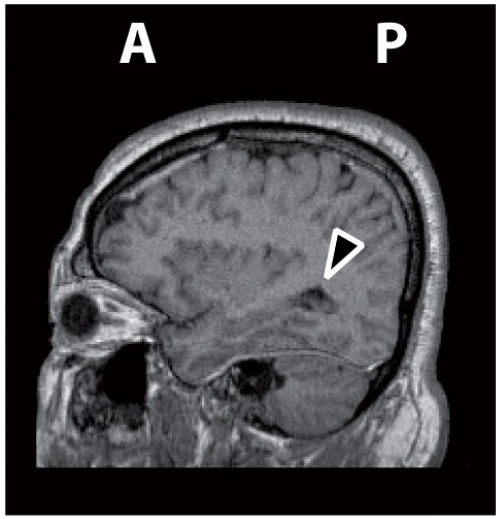
Specialized feature processing in the human brain



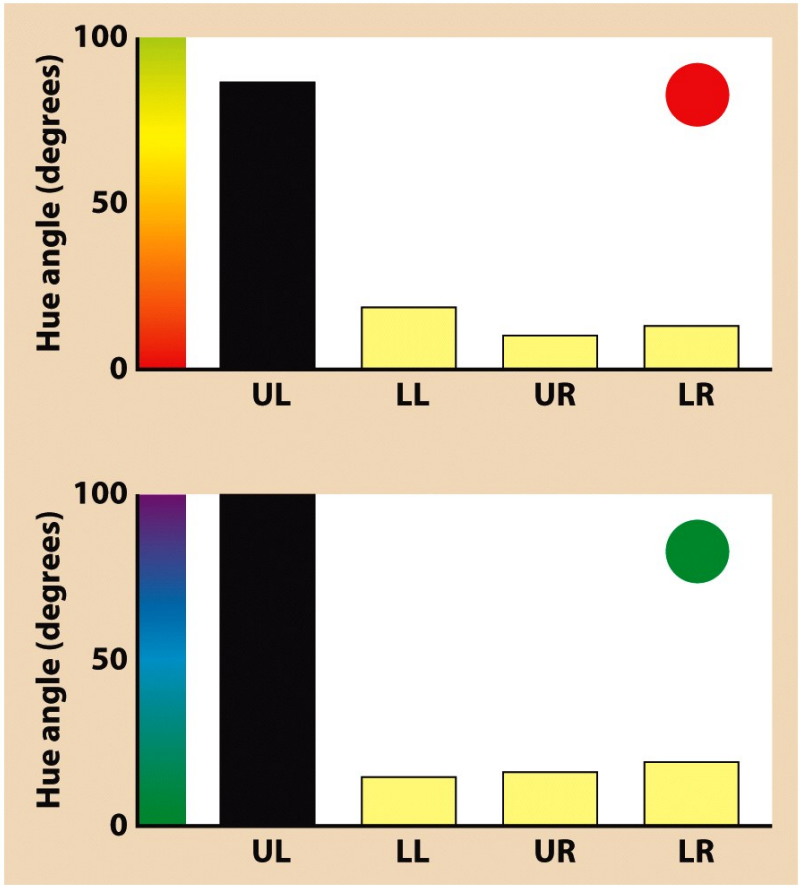
Zeki, S., 1993.

Color perception with a unilateral lesion of V4

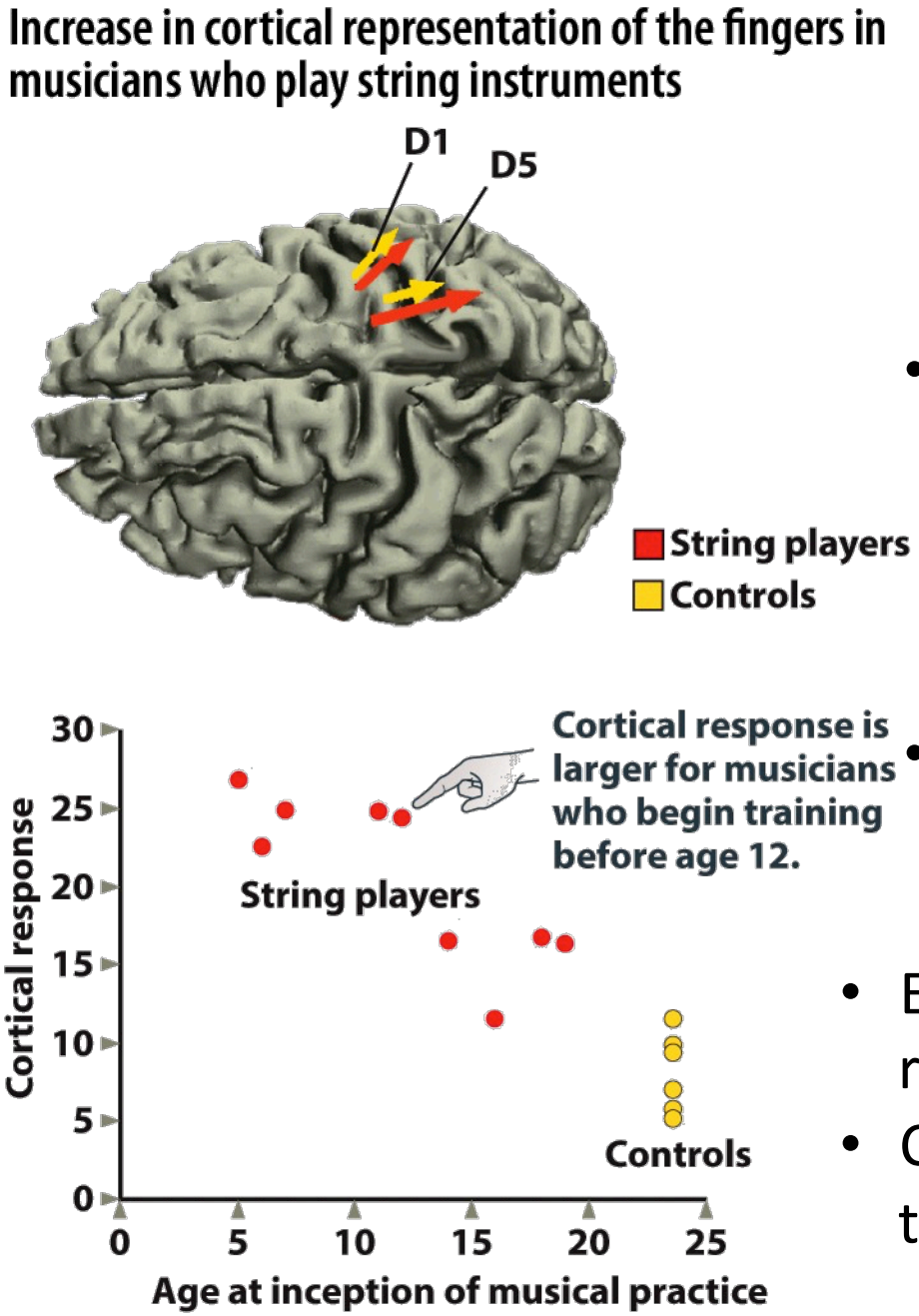


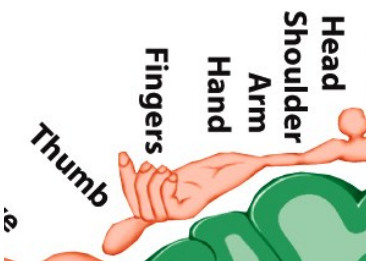


UL = upper left
LL = lower left
UR = upper right
LR = lower right



the color required to detect a difference between a patch each visual quadrant and the target color shown at the fovea

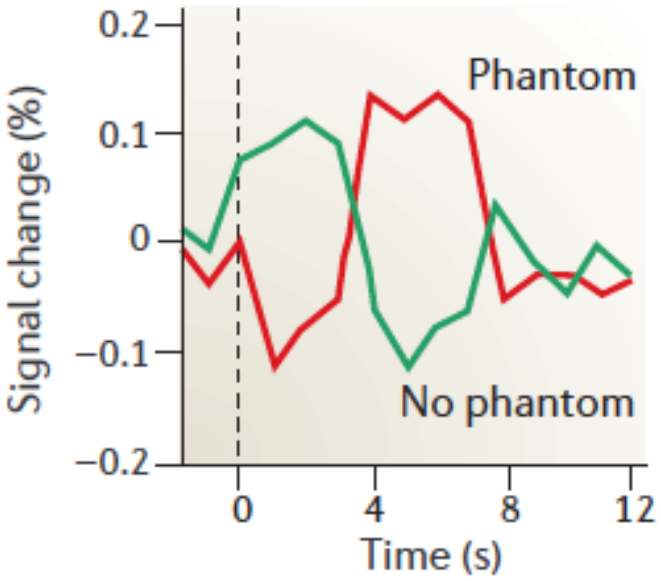


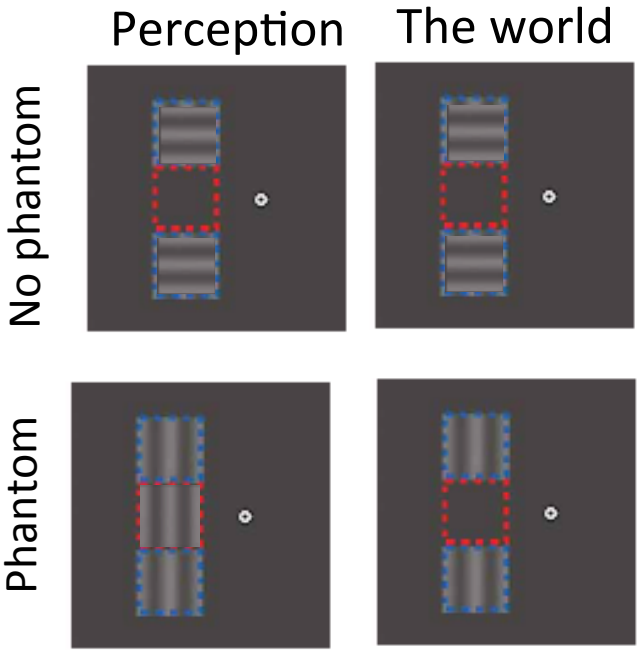


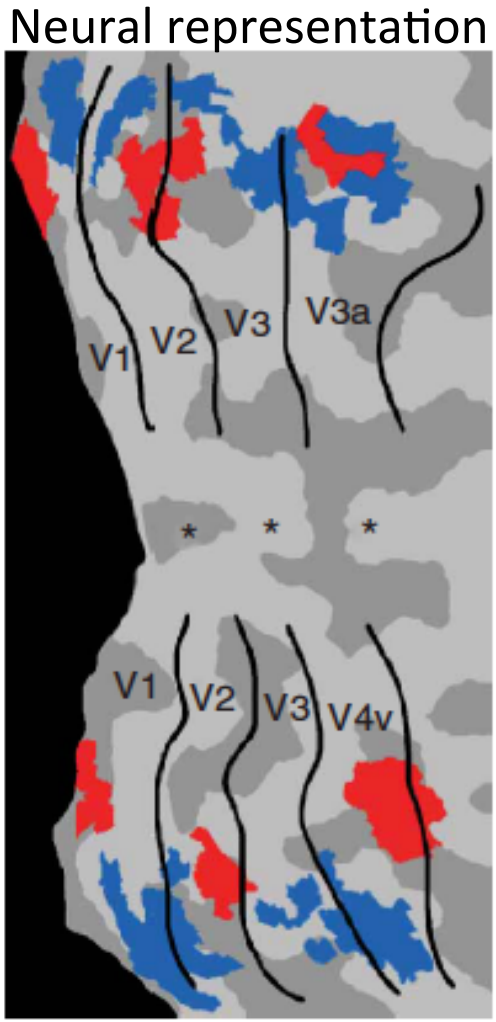
- Larger responses in somatosensory cortex following stimulation of thumb (D1) and pinkie (D5) for musicians than controls
- For musicians, the earlier musical training stated, the larger responses
- Enhanced thumb sensory representation for smartphone users
- Can be induced with just 10 days of touch screen use

Gindrat et al. (2015)

Perceptual Filling-in: Reconstructive



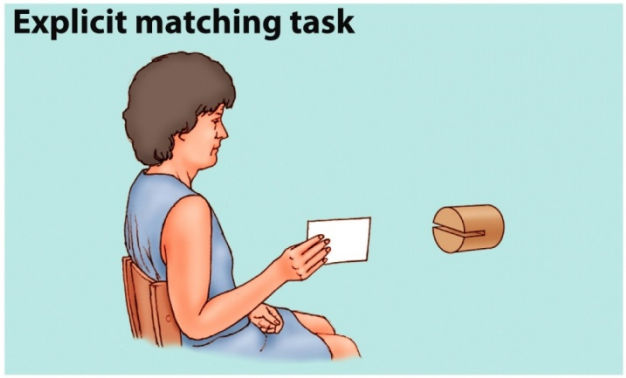


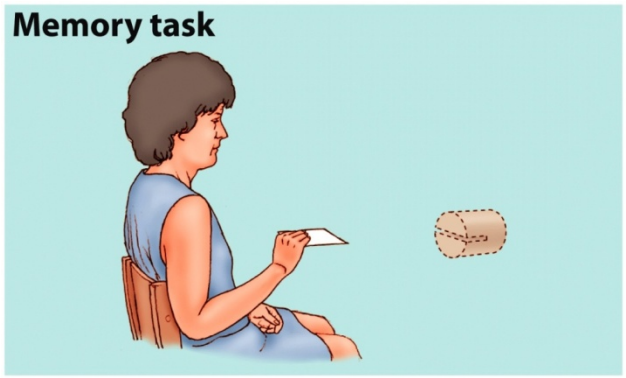


- The activity in the gap region (red square) increased after the phantom was perceived, and decreased when the phantom disappeared
- Providing the neural mechanisms of perceptual filling-in

Meng et al. (2005)

Ventral “what” pathway lesion





- Bilateral LOC damage
- cannot recognize objects
  - can’t tell the orientation of the slot
- but knows *“how”* to act on them (or spatial location)
  - post a letter into it
  - also intact memory for action
  - Dorsal ‘where or how’

Sufficient versus necessary

- Necessary– if you damage it, that function goes away
  - Damage LOC, see object recognition damage
  - Same with Temporal lobe
- Sufficient – you only need one region for the function
  - Impossible to prove with neuropsych

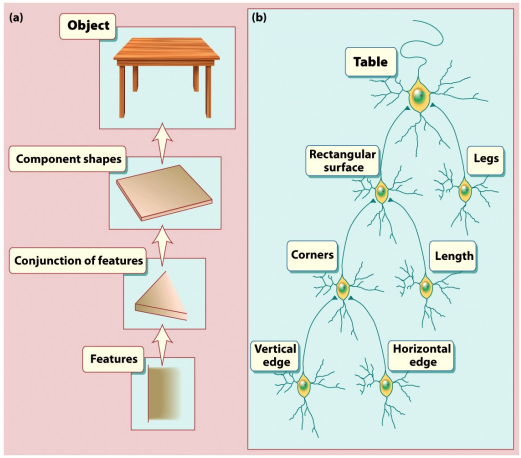
Grandmother versus Ensemble

Grandmother cell

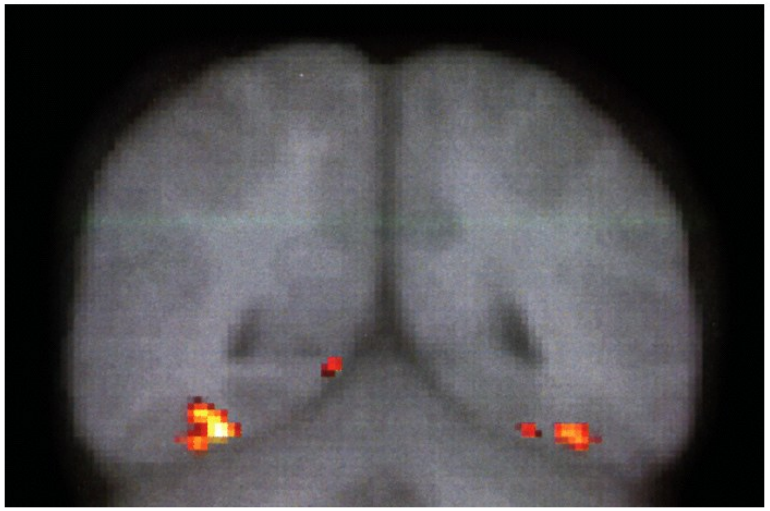
- One cell needed for every angle of your grandmother
- If lost, you can no longer perceive grandmother from that angle

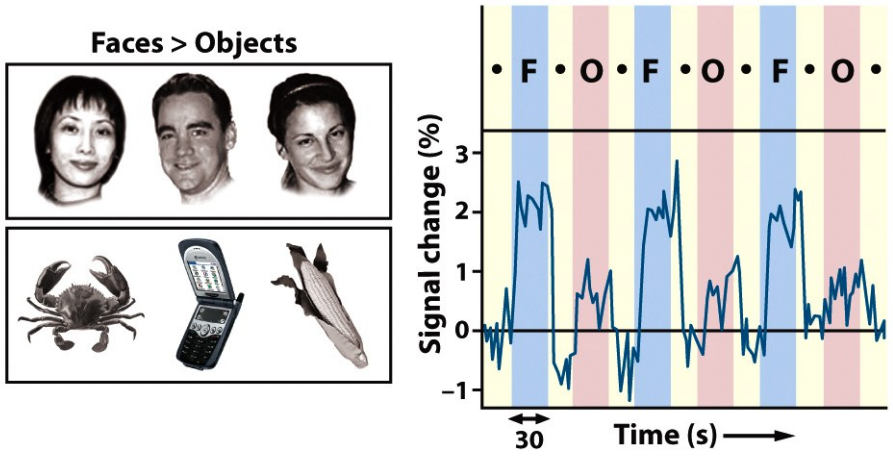
Ensemble

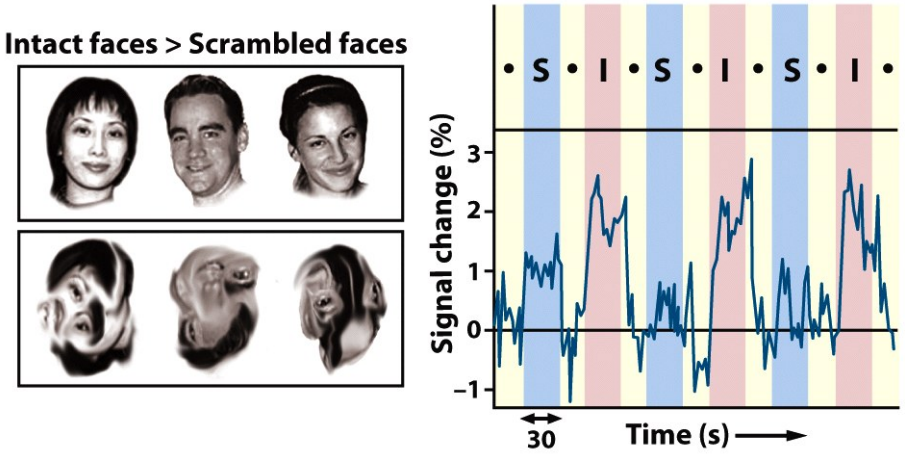
- Many neurons contribute to the cell (different attributes)
- If you loose one of them, you can still perceive your grandmother



Fusiform Gyrus

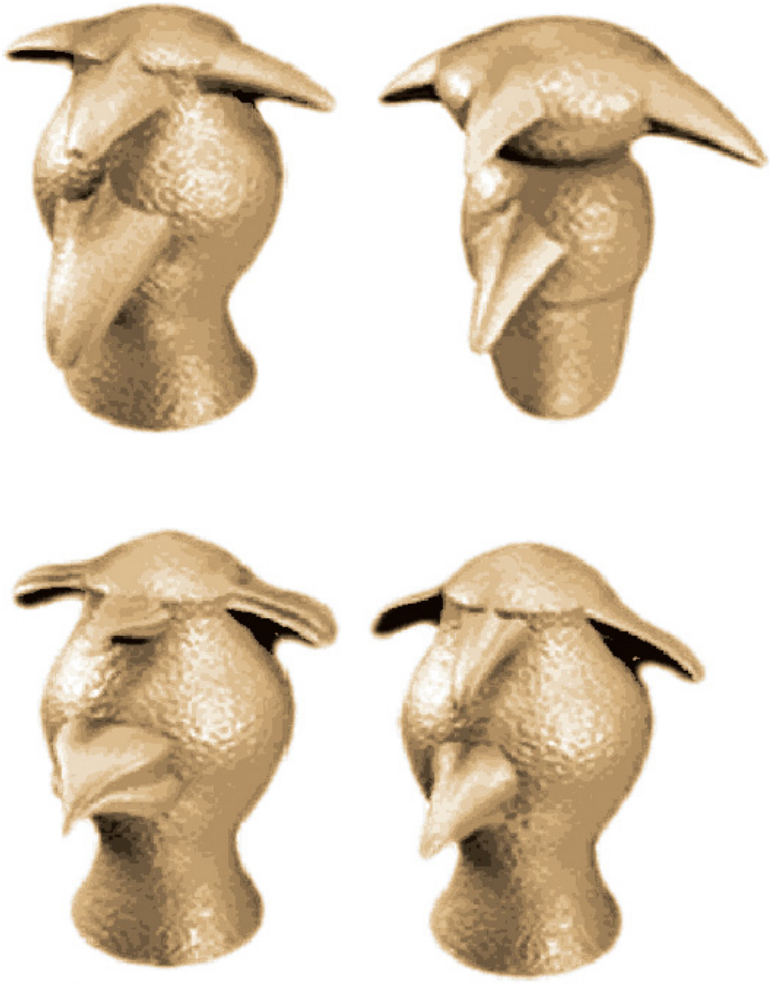




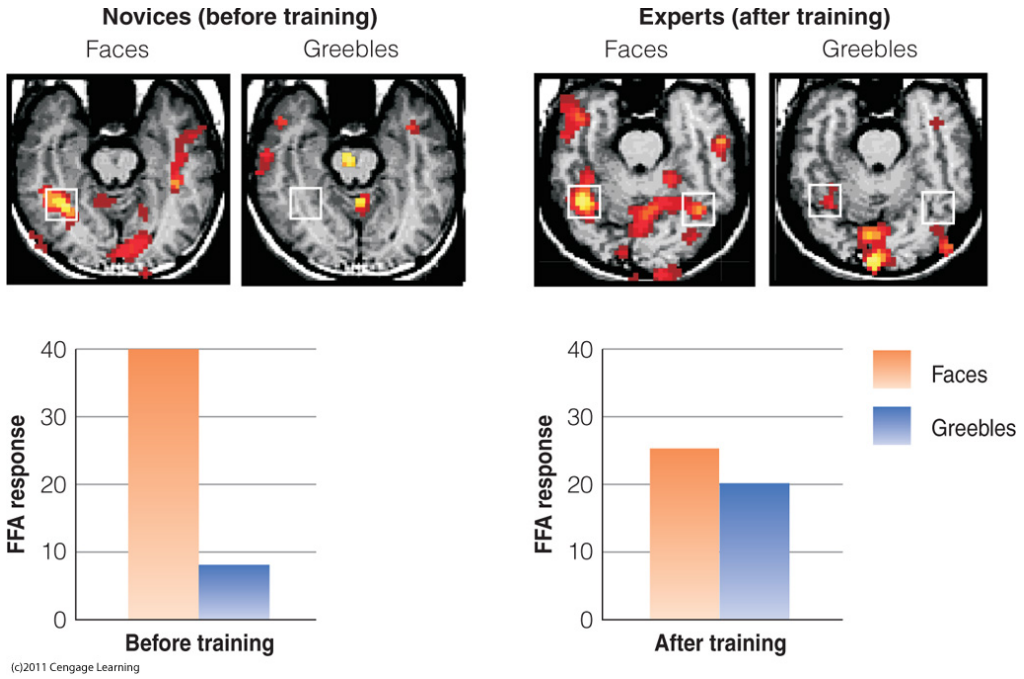


Why using scrambled face?

Expertise, yes!



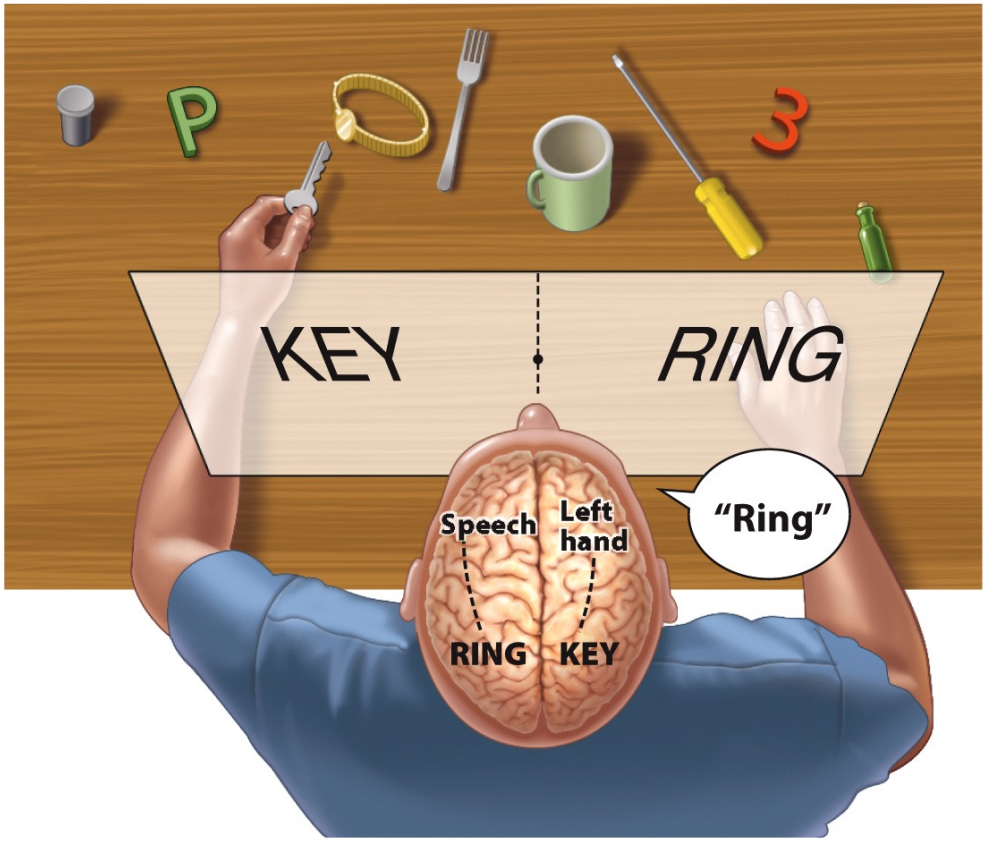
Greeble stimuli used by Gauthier. Participants were trained to name each different Greeble.



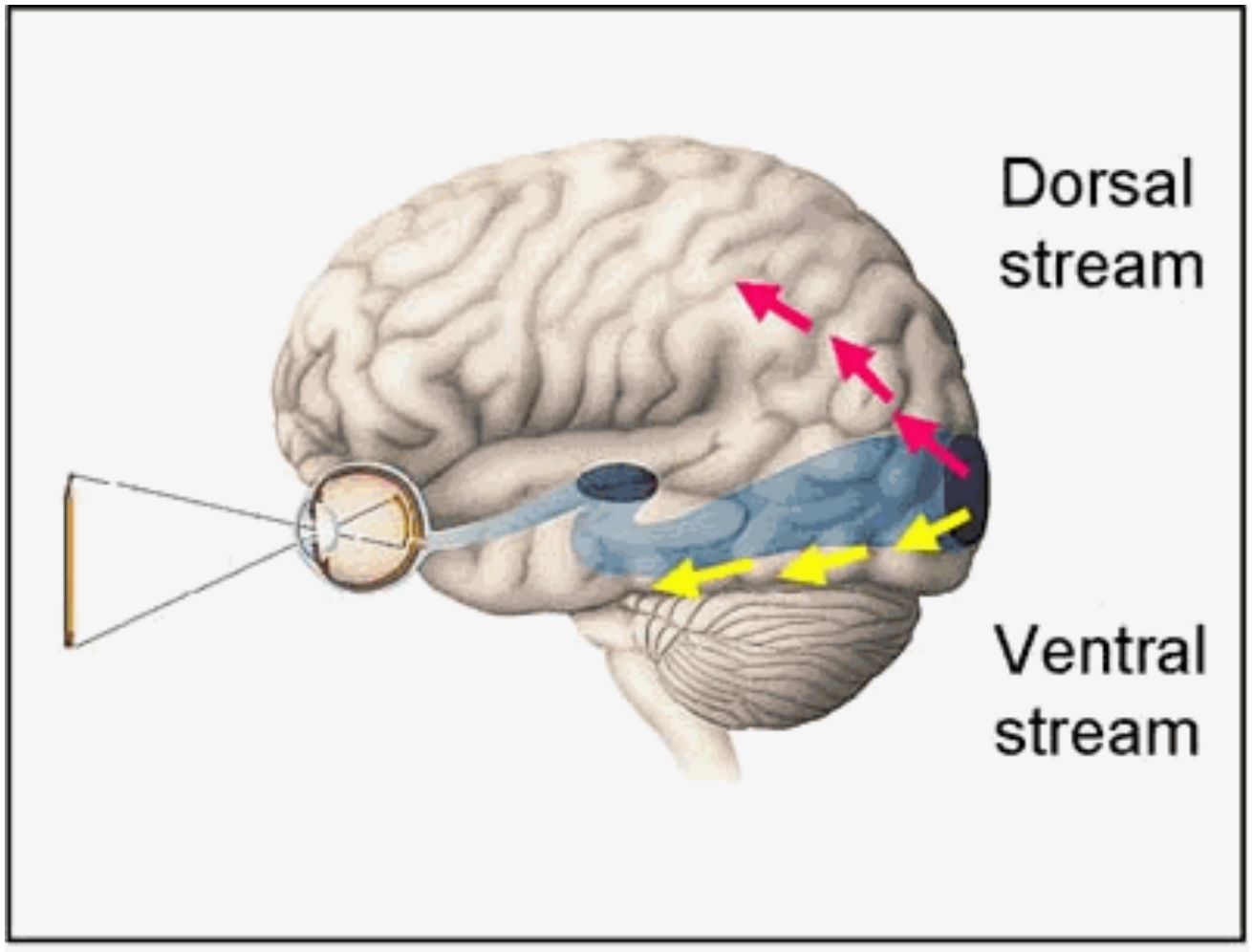
Magnitude of brain responses to faces and Greebles (a) before and (b) after Greeble training. The colored areas in the brain records indicate brain activity. The FFA is located within the white squares.

Training modulates FFA activities

- Left hemisphere – language production, right hand
- Right hemisphere – visuospatial, left hand



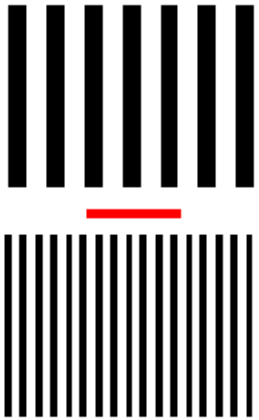
Dorsal and ventral pathway in both hemispheres

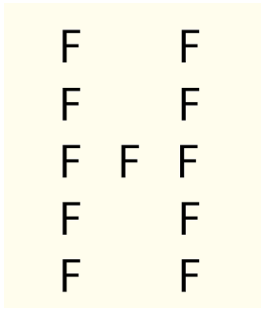


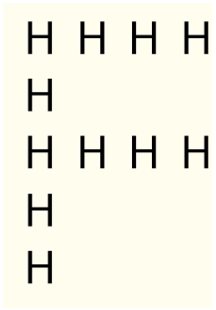
- LH - better at processing high spatial frequency information
  - Allows perception of details/edges (local)
- RH - better at processing low spatial frequency information
  - Allows perception of whole/overall shape (global)

LSF - Global

HSF - Local



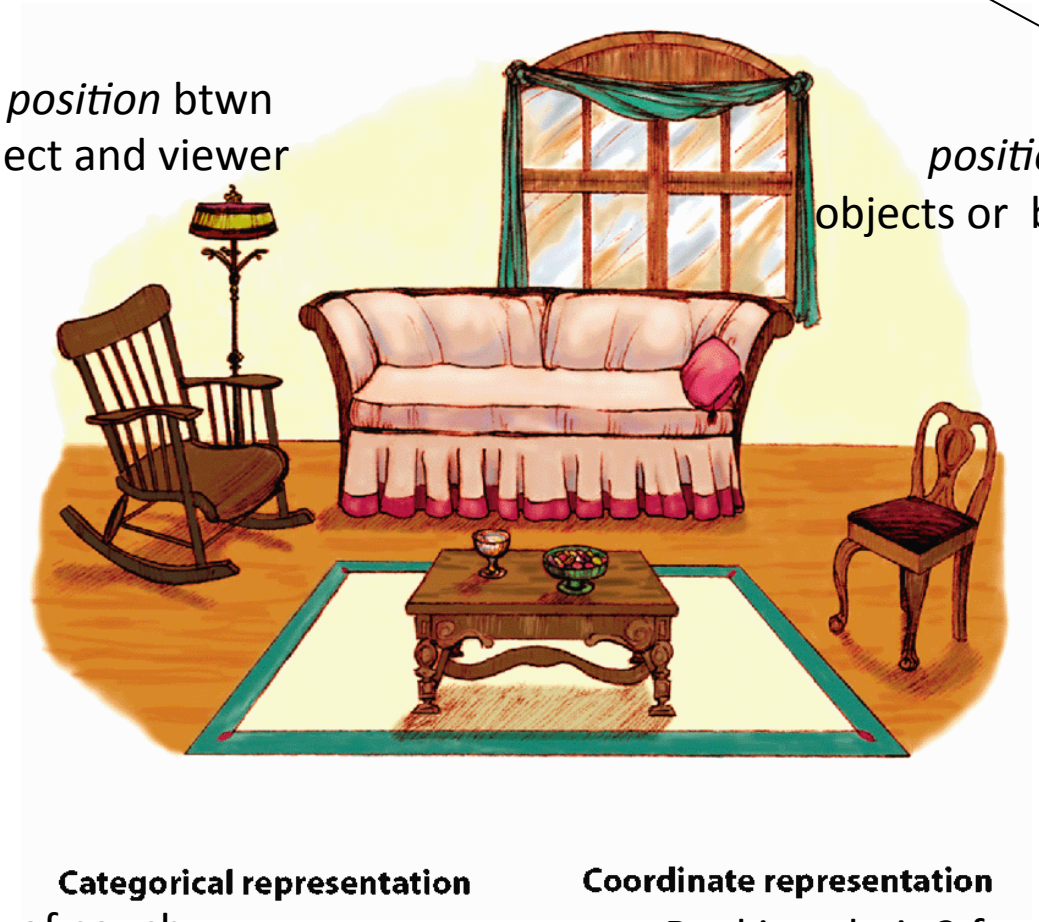




Categorical vs Coordinate Reps

Specify the *relative position* btwn objects or btwn object and viewer

Specify the *exact positions and distances* btwn objects or btwn object and viewer



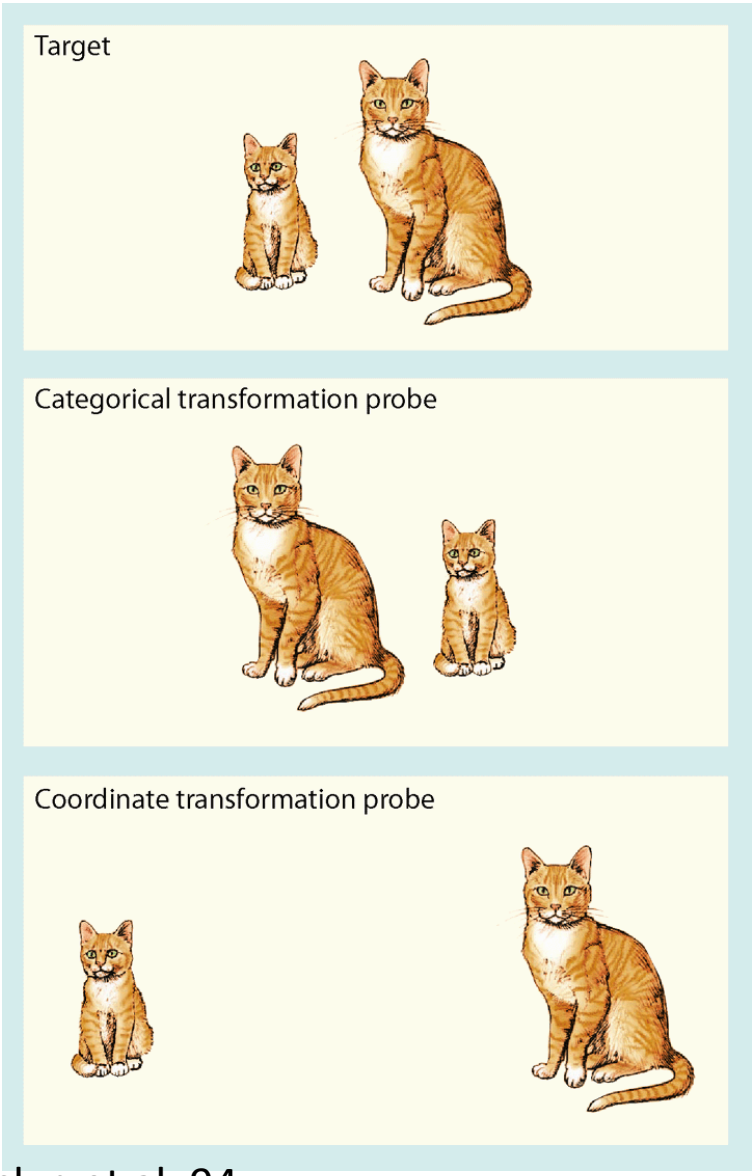
Categorical representation

Rocking chair <u>left of</u> couch
Dining chair <u>right of</u> couch

Coordinate representation

Rocking chair <u>2 feet from</u> couch;
Rocking chair <u>closer than</u> dining chair to couch

Kosslyn



TASK: delayed match to sample

Categorical – left hemisphere

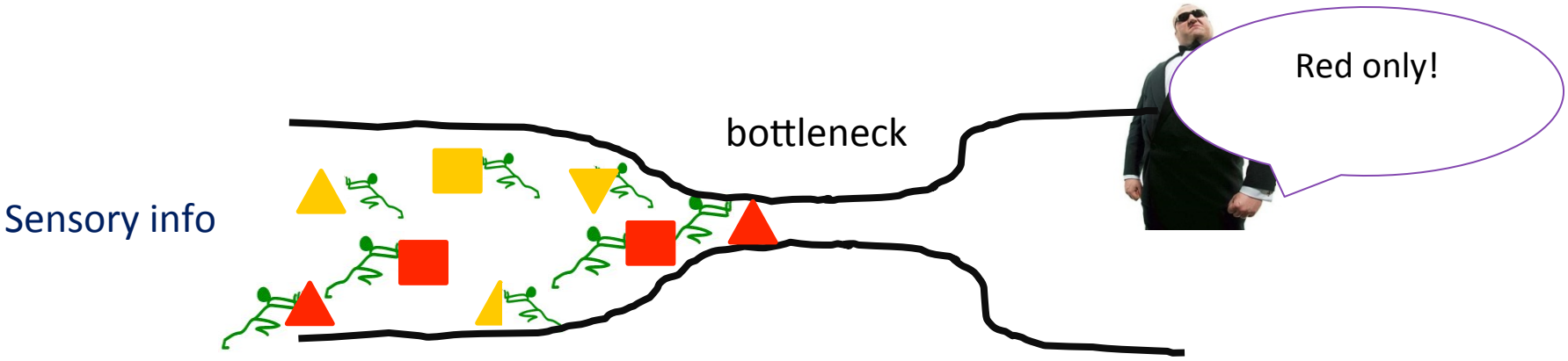
Coordinate – right hemisphere

Kosslyn et al. 94

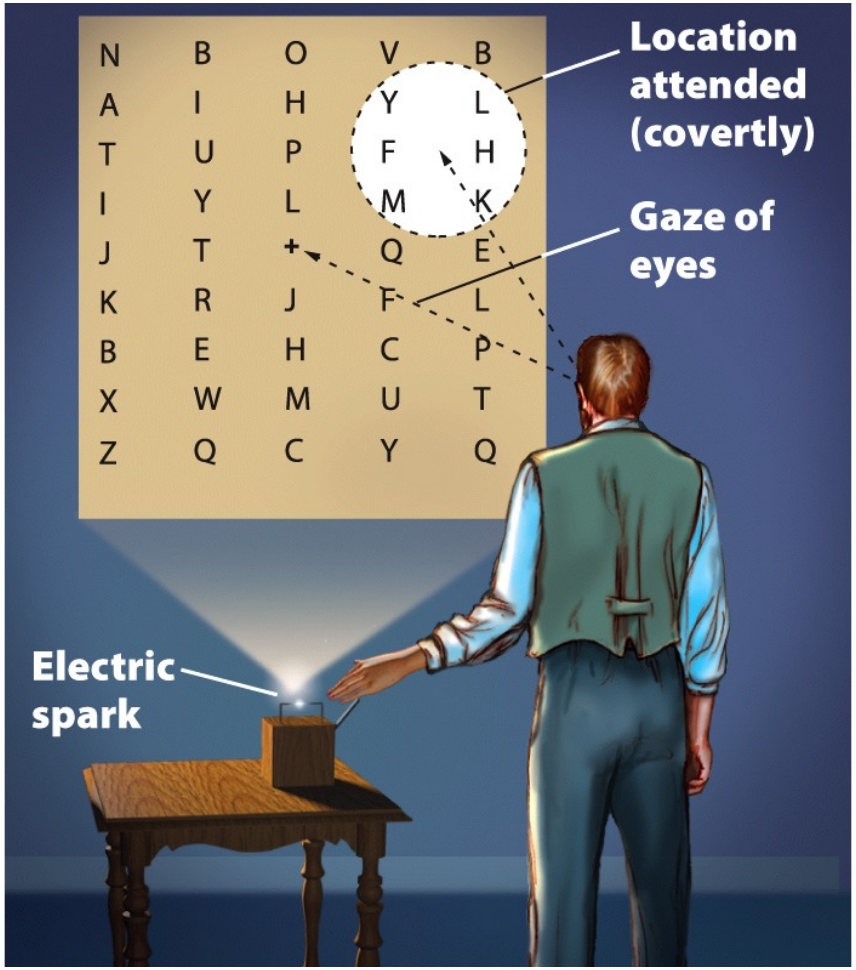
- Voluntary versus reflexive
  - Voluntary – conscious orienting (top-down)
  - Reflexive – unconscious orienting (bottom-up)
- Covert versus overt
  - Covert – eyes DO NOT focus on location of attention
  - Overt – eyes DO focus on location of attention

Limitations in processing can be described as a “bottleneck”

Attention selects goal relevant information



Could happen early or late



Hermann von Helmholtz (1821–1894)

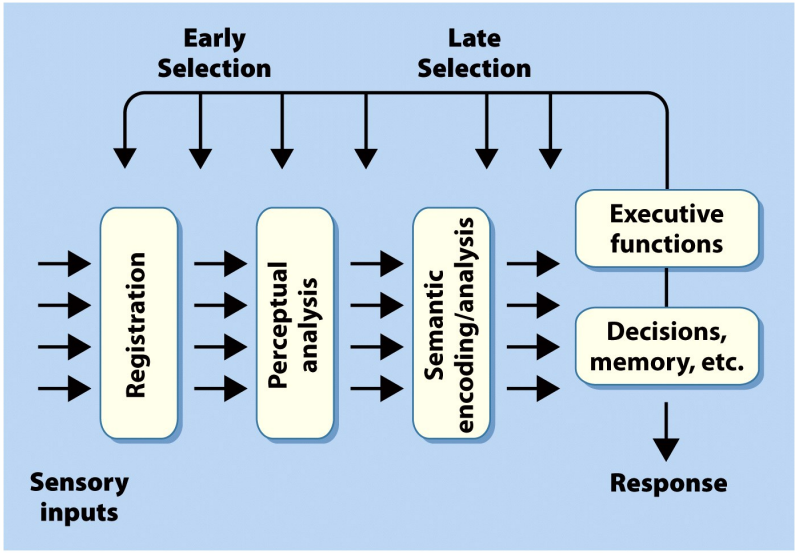
Bettmann/Corbis

First experimental evidence of covert attention

Is attentional selection early or late?

Tune out spouse's voice

Volume control

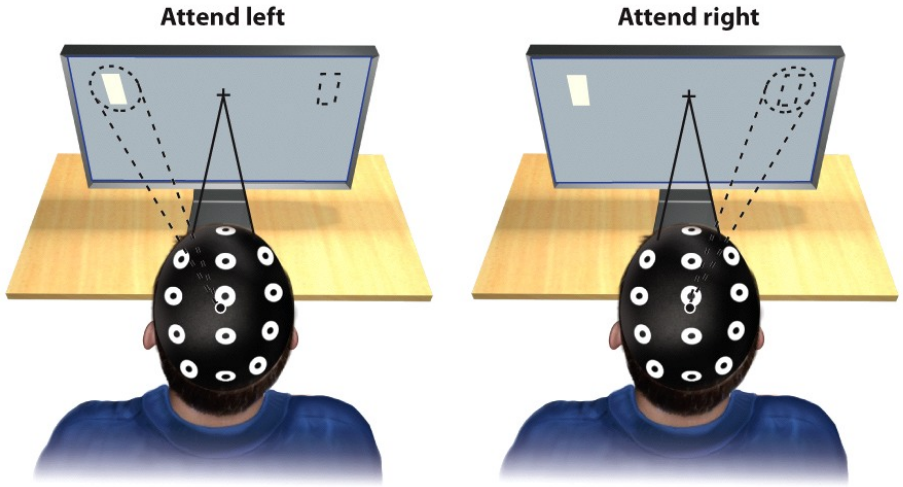


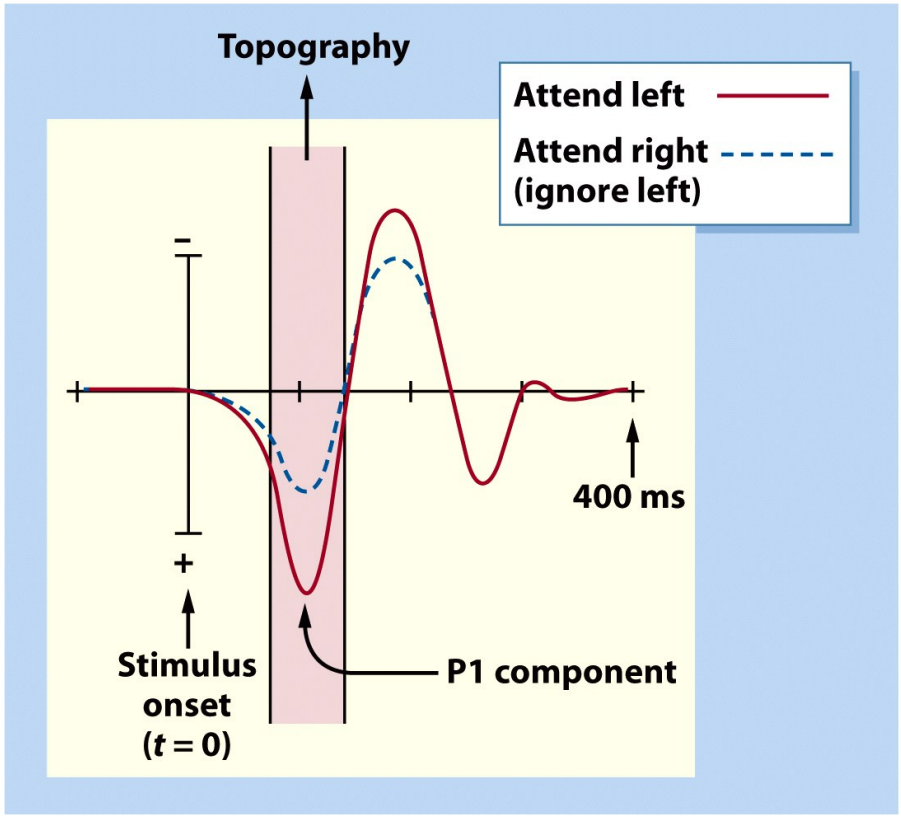
Still hear spouse's voice, but ignore it

Early – select or dampen sensory information

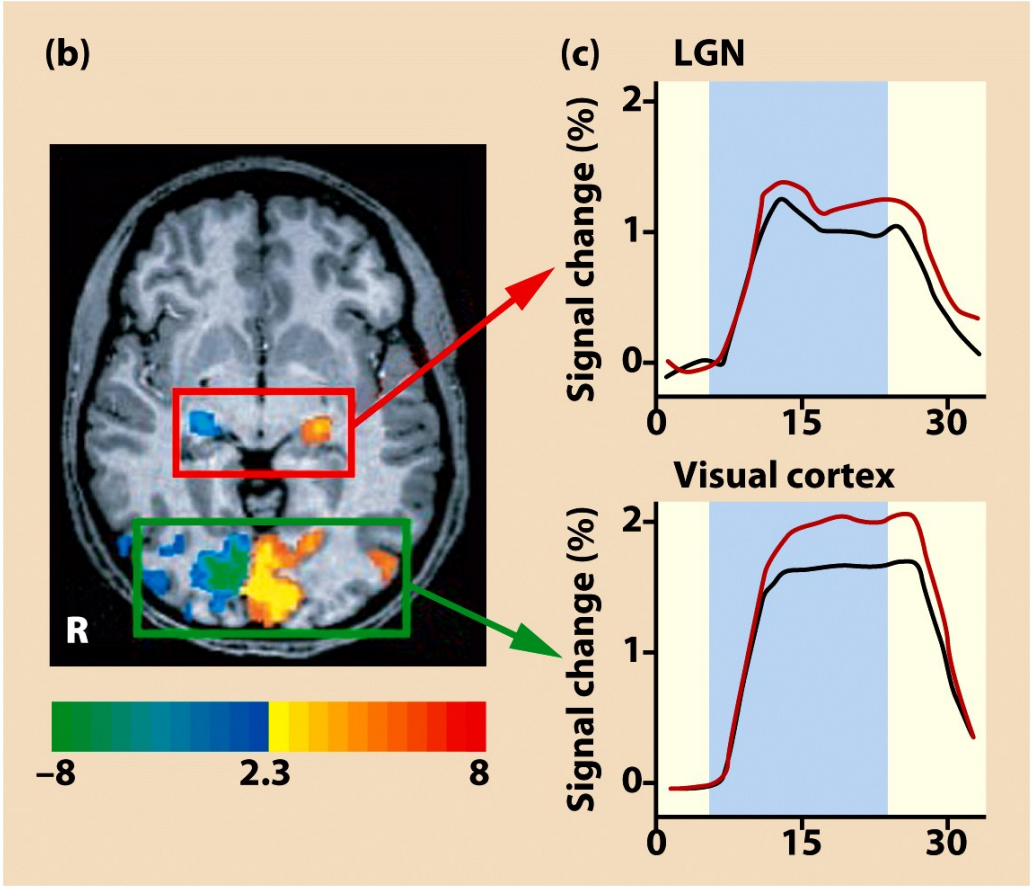
Late – select or ignore information after semantic analysis is done

- ERPs
  - See brain activity difference as early as 70ms (early in perception)

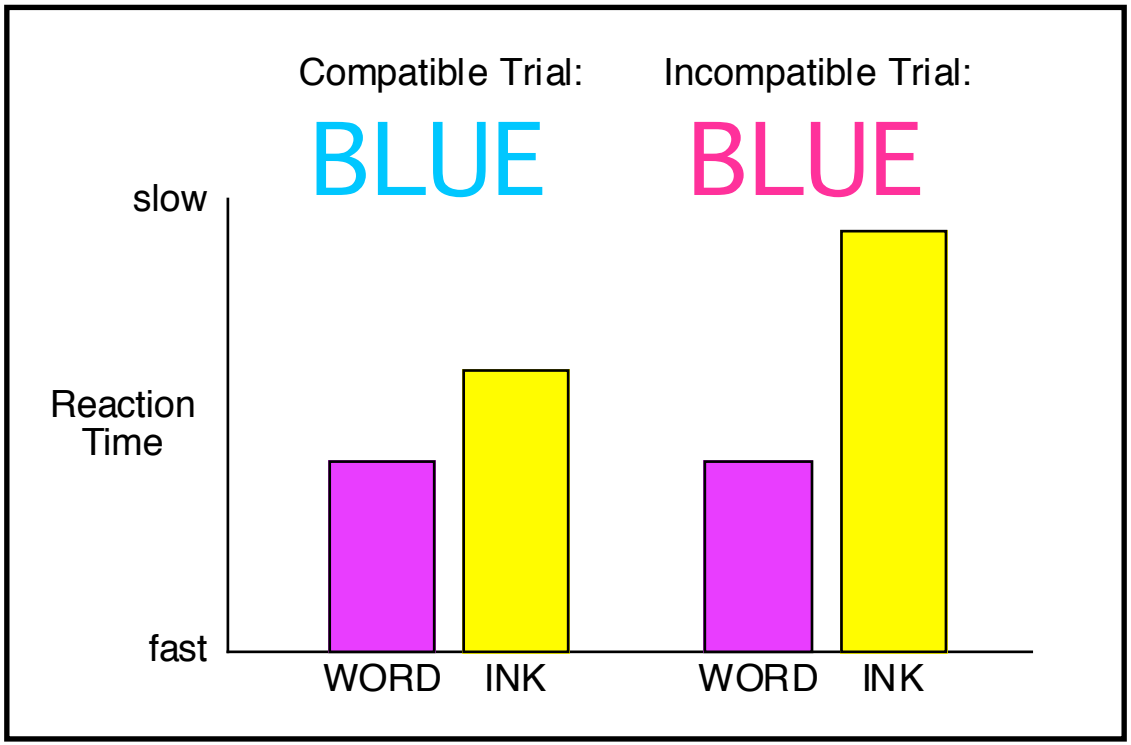




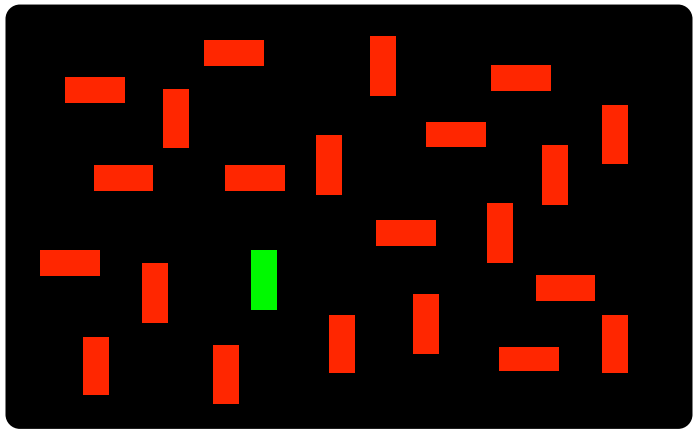
- fMRI
  - See brain activity in LGN and V1 affected by attention

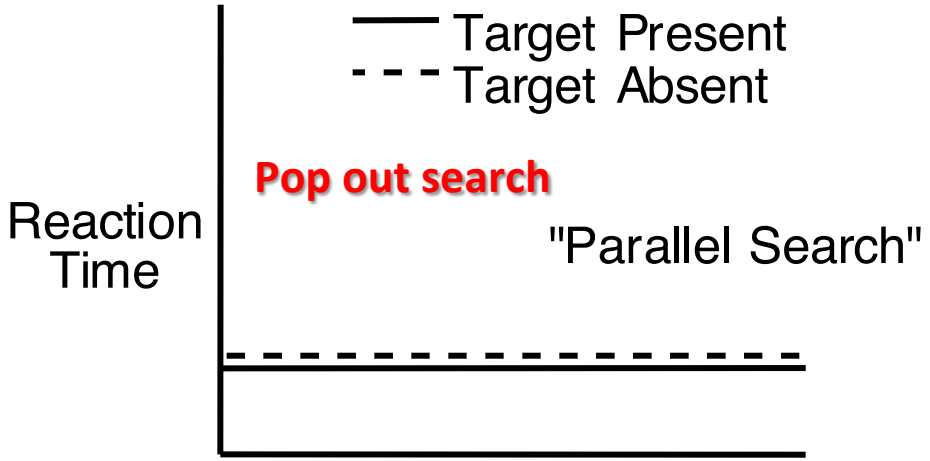


- Stroop
  - Attend to color (if blue, push button)
  - Semantic information interferes with task
    - Attention affected after semantic analysis

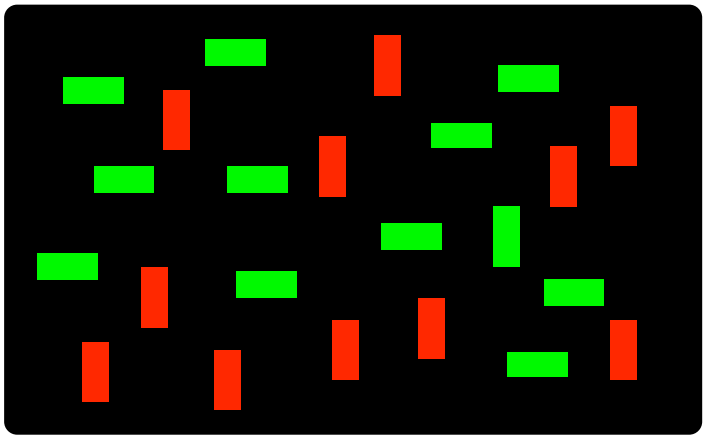


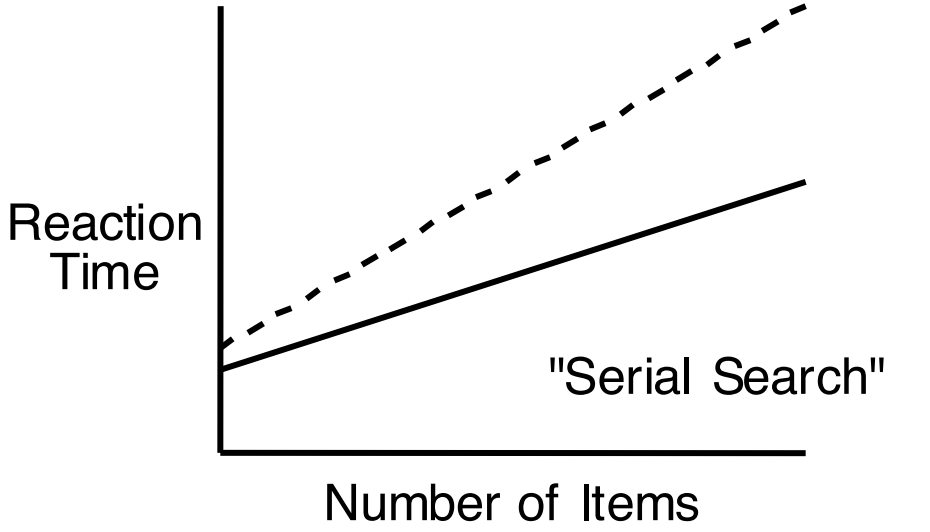
Feature Search



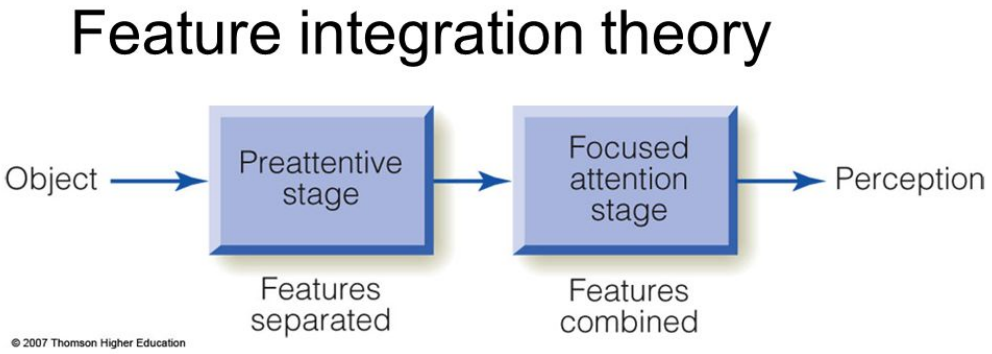


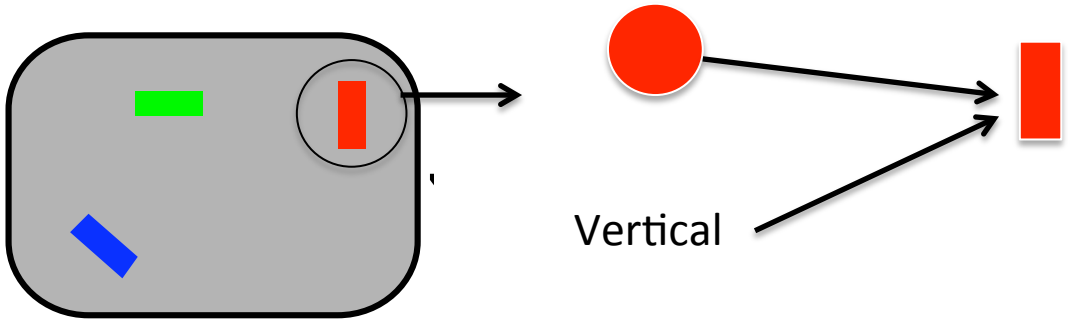
Conjunction Search



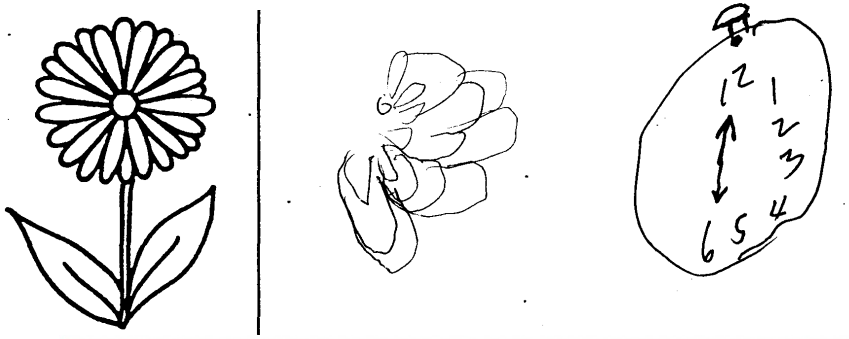


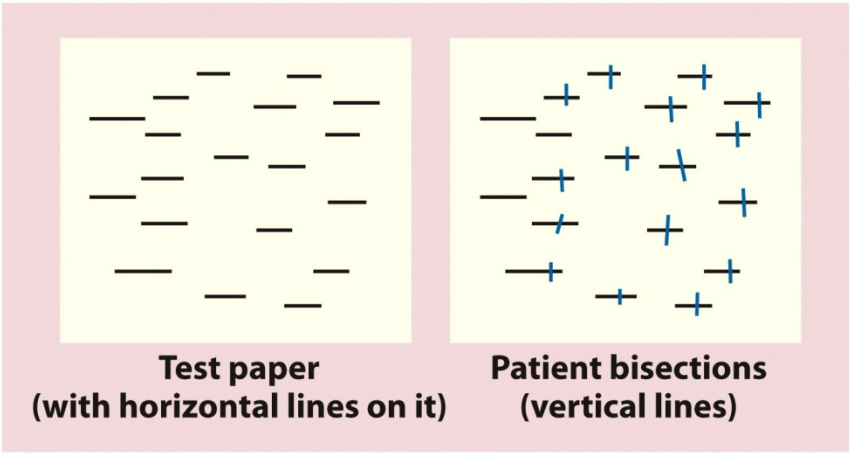
- Feature integration theory –
  - Preattentive stage – features *are not* bound together
    - 'Free floating', separate maps…
  - Attentive stage – features *are* bound together
    - 'Localized', one object file

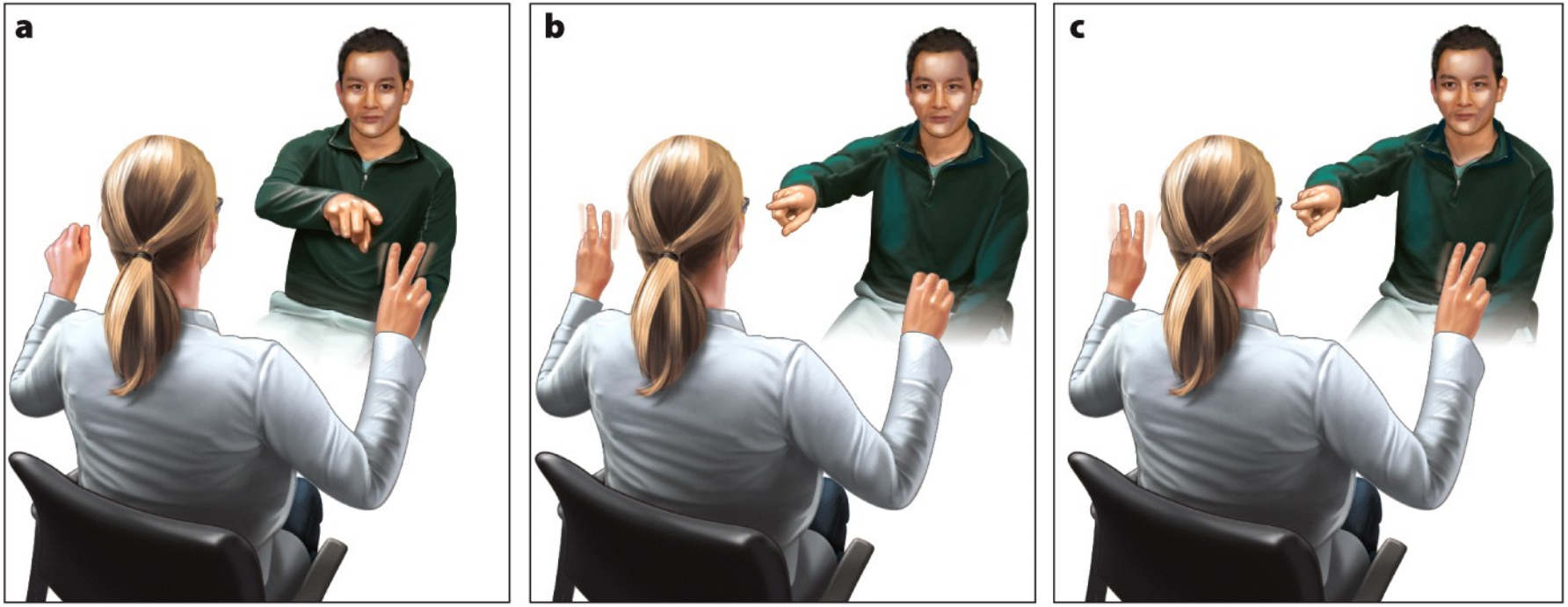




- Ignore contralesional space
- Sensory perception (ability to “see”) intact
- But can direct voluntary attention to neglected side (slower though)
- Sensory-driven (reflexive) attention very impaired



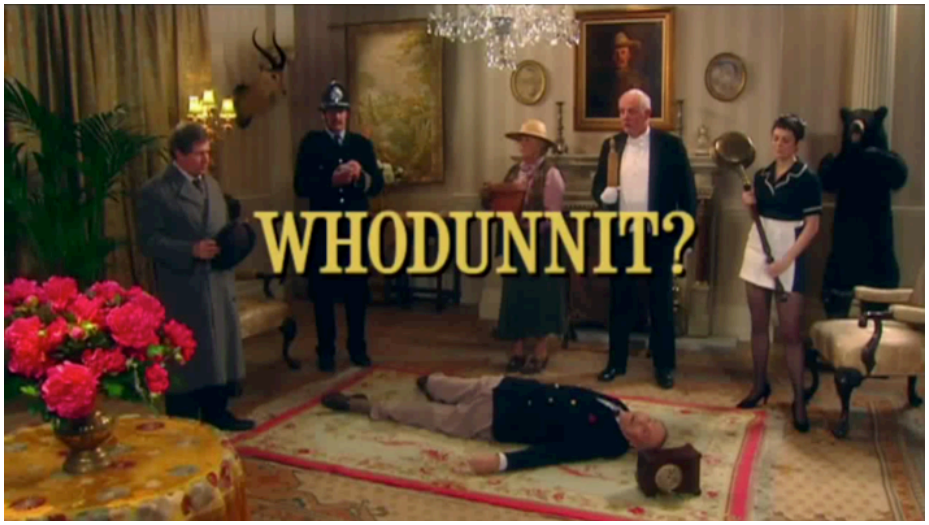




- Detect and respond (by pointing) to the stimuli if presented one at a time, suggesting no major visual field defects
- However, see only the one in the right visual field when bilateral stimuli were presented simultaneously
- **Extinction**: the simultaneous presence of the stimulus in the patient's right field leads to the stimulus on the left of the patient being extinguished from awareness

Attention

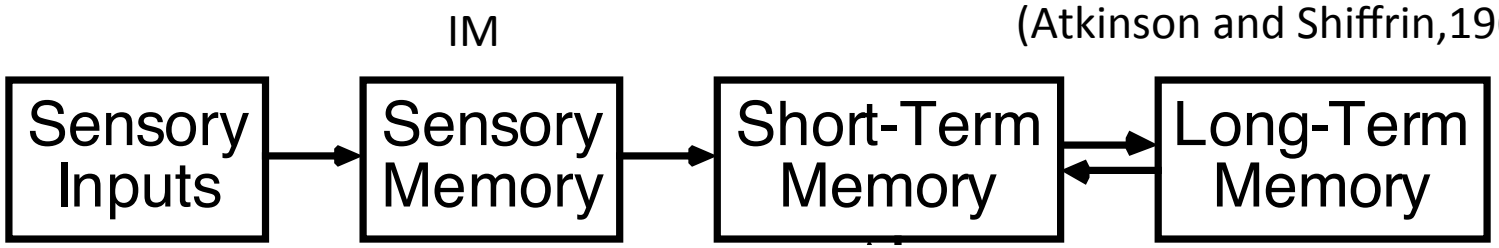
- Inattentional blindness – failure to notice the existence of an unexpected item
- Change blindness – failure to notice an obvious change




NICE

Memory systems

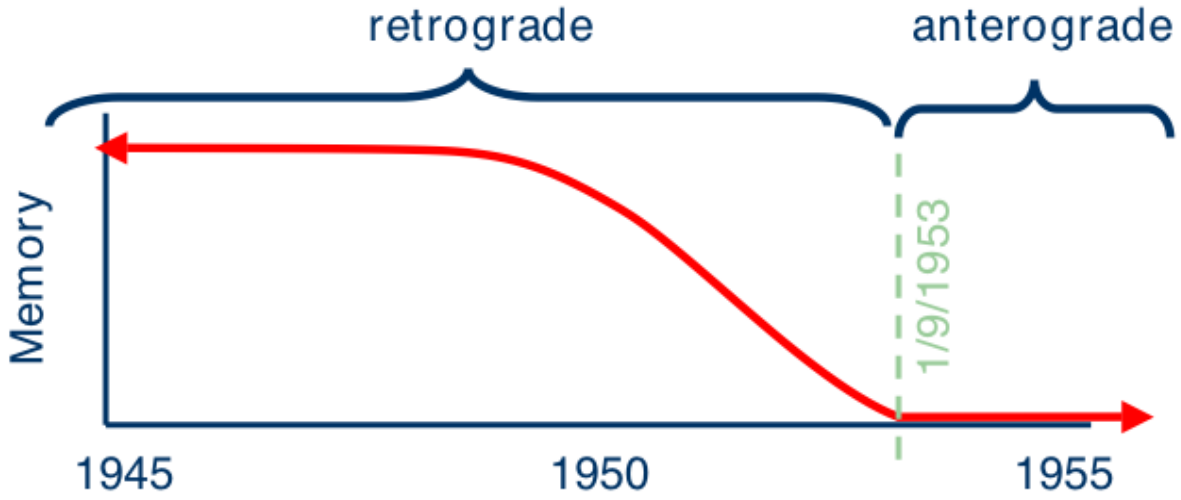
Modal/stage model
(Atkinson and Shiffrin,1968)



	STM	LTM
Capacity	Limited (~3)	Unlimited Standing (1973)
Lifetime	Limited (forgetting after a few seconds) Peterson & Perterson	Unlimited (retrieval problem)

Amnesia – loss of memory

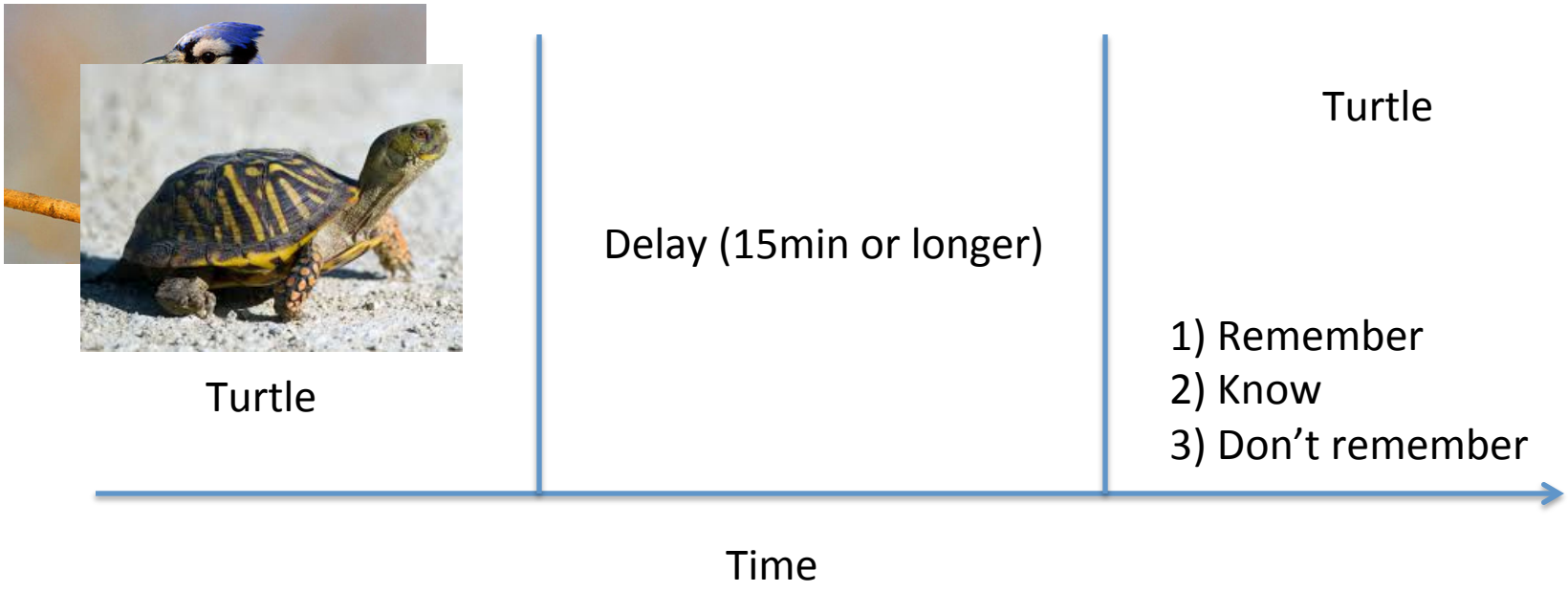
H.M.



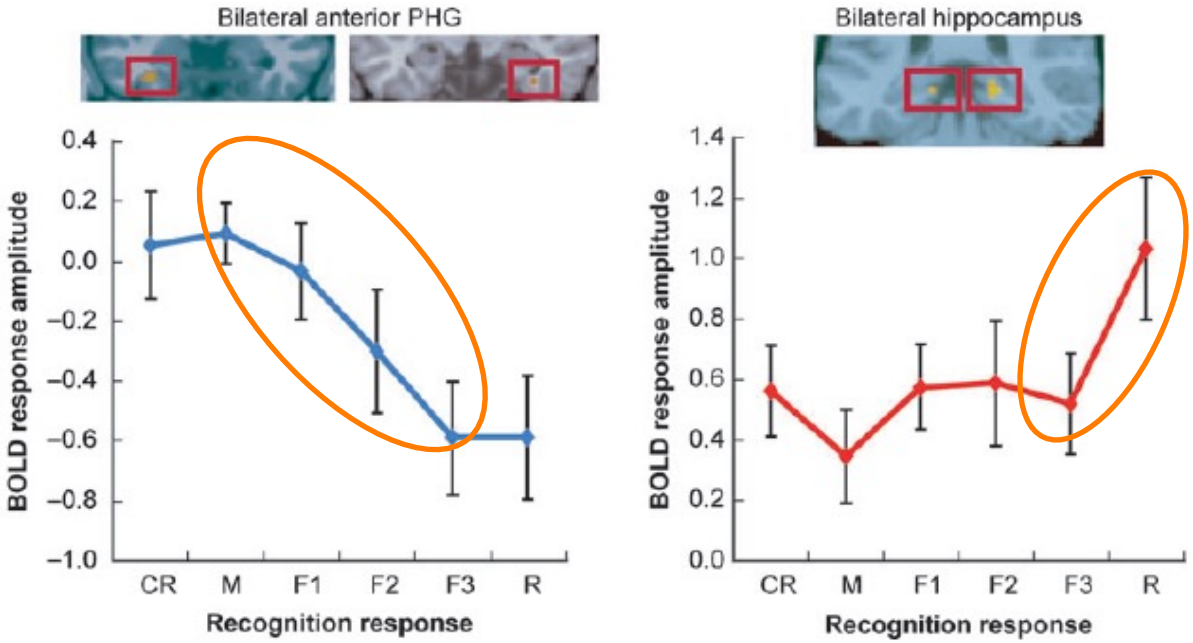
- Recollection (R): slow search process, qualitative information
  - Binary (either recollect or not)

- Familiarity (F): fast process, familiarity or a ‘sense of recency’
  - Graded/continuous (e.g., strong or weak feeling of knowing)

Remember/know paradigm



- Remember – can recall details (recollection)
- Know – know it was presented, but don't remember details (familiarity)

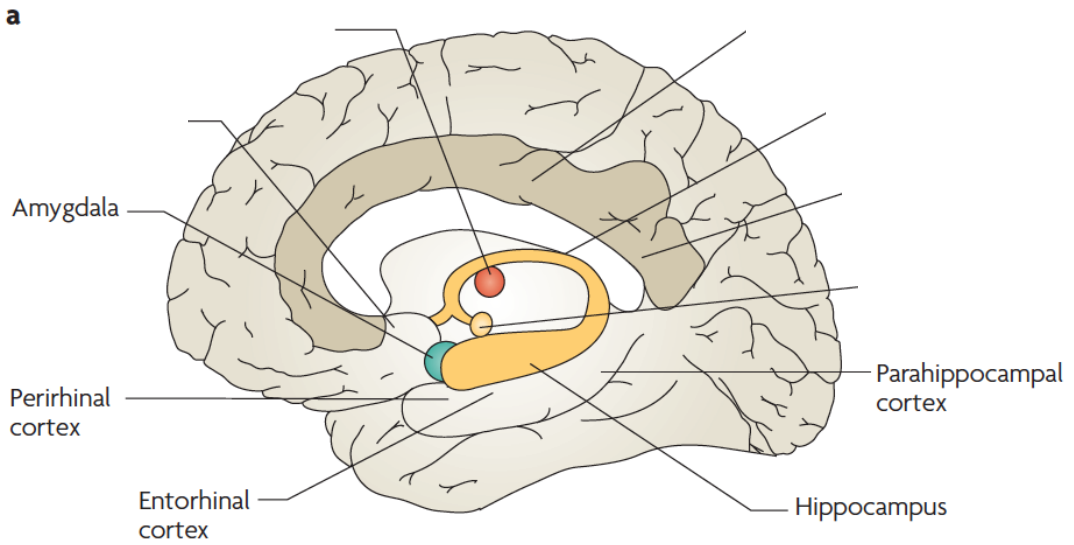


Remember (R) and Know (familiarity confidence F1,F2, F3) responses.
CR: correct rejection of lures; M: missed target

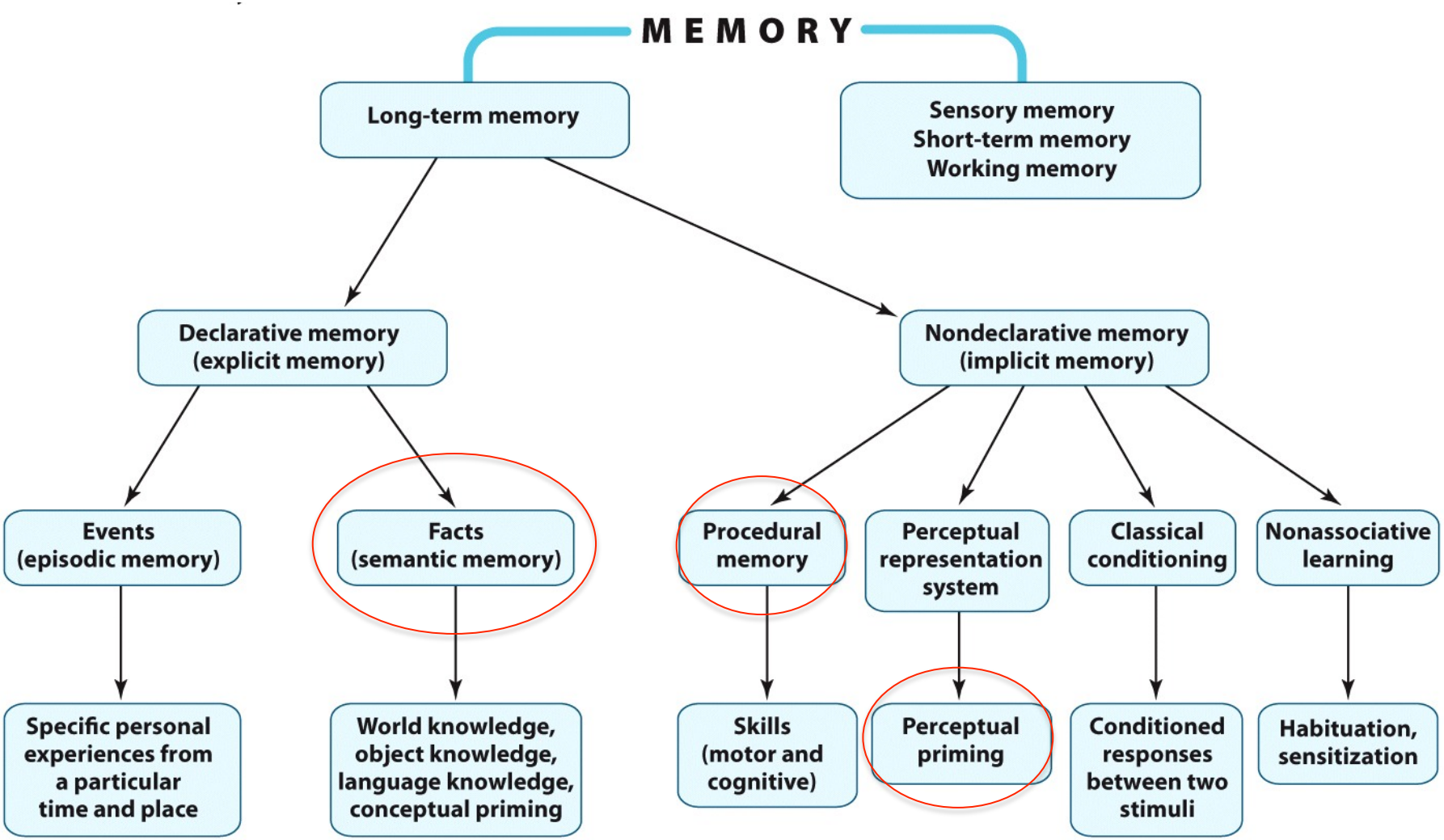
- Hippocampus was related to recollection, but not familiarity
- Parahippocampal gyrus activation scales with subjective familiarity judgments, and was related to familiarity, but not recollection

Montaldi et al., (2006)

Medial temporal lobes (MTL)

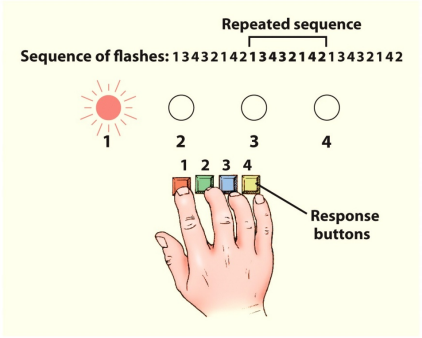


- Hippocampus - R
- Parahippocampal gyrus - F
  - Entorhinal cortex
  - Perirhinal cortex - F
  - Parahippocampal cortex


MEMORY
Long-term memory
Sensory memory
Short-term memory
Working memory
Declarative memory
(explicit memory)
Nondeclarative memory
(implicit memory)
Events
(episodic memory)
Facts
(semantic memory)
Procedural
memory
Perceptual
representation
system
Classical
conditioning
Nonassociative
learning
Specific personal
experiences from
a particular
time and place
World knowledge,
object knowledge,
language knowledge,
conceptual priming
Skills
(motor and
cognitive)
Perceptual
priming
Conditioned
responses
between two
stimuli
Habituation,
sensitization

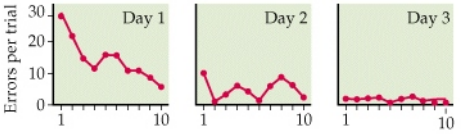
Implicit LTM tasks

- Procedural memory intact in amnesia patients
  - Sequence learning – procedural



  - Mirror tracing - procedural

(b) Performance of H.M. on mirror-tracing task



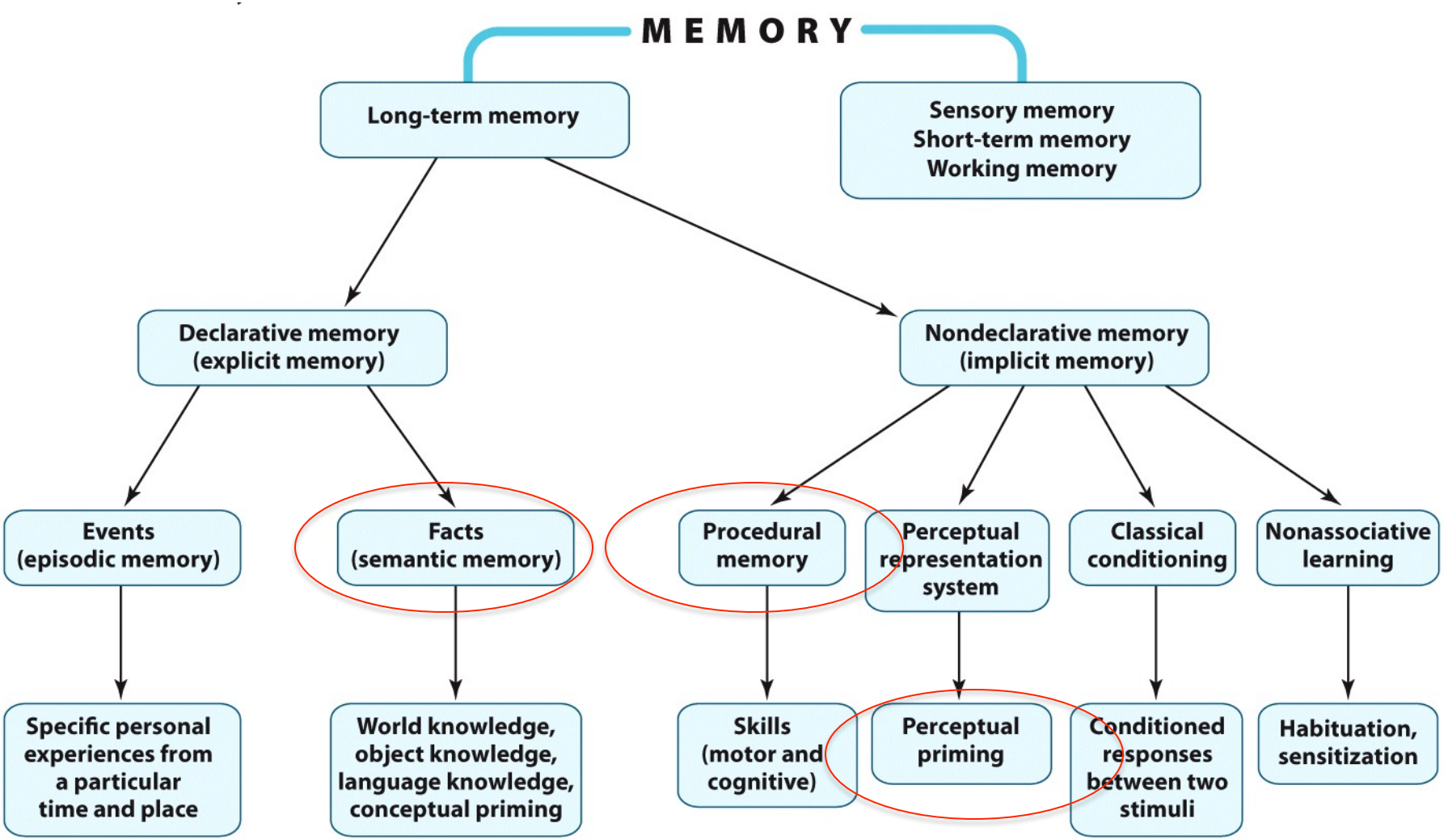
How Did You Do in the Vowel Counting Task?

New Words		**Old Words from Vowel Counting**	
corvette	?	clarinet	?
asbestos	?	tequila	?
hexagon	?	ellipse	?

-Increased likelihood of solving the fragments if the words had been studied.

-Example of implicit memory or what is sometimes called priming.

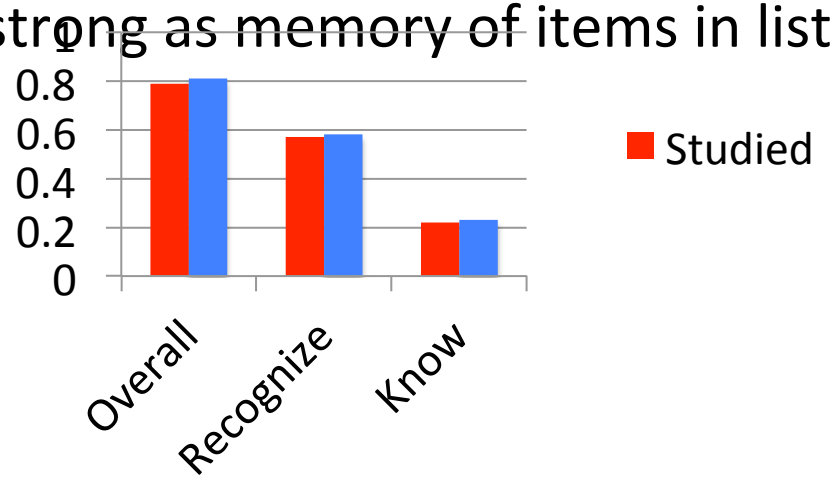
Beyond Episodic Memory



Some semantic memory, procedural memory, and semantic priming in Amnesic, suggesting these memory subsystems may be less dependent on MTL

False memory

- DRM paradigm/ word recall task
  - Lists created based off of one word (sleep, bread, etc.)
    - Critical lure, intrusion word
  - ~40% people remember critical lure
    - Just as strong as memory of items in list



Defining emotions: 2 approaches

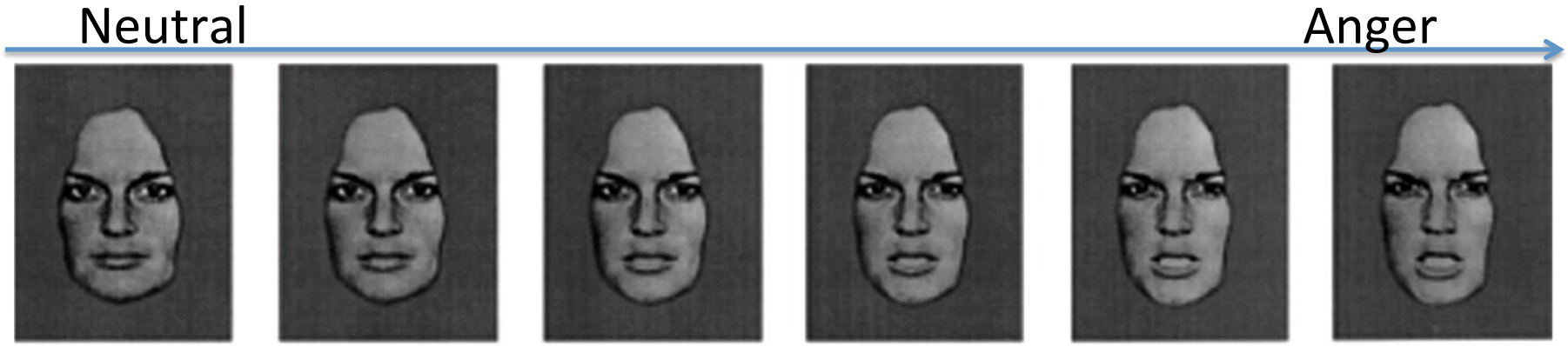
1. Classify *basic emotions*
   - Ekman: asked people to identify facial expressions: *each emotion a discrete state (Darwin hypothesis)*
   - Universal: appear to be true across different cultures.
   - Innate
   - Precursor in primates
   - Further studies look for neural/ physiological systems associated with each basic emotion

Ekman's (1972) list of basic emotions:

- Anger
- Disgust
- Fear
- Happiness
- Sadness
- Surprise

Defining emotions: 2 approaches

2. Classify *dimensions of emotion*
   - Describe emotions as reactions to events where e*ach emotion is a continuous state*
     - e.g. a little happy if you win a $5 raffle, but a lot more happy if you win $500,000.

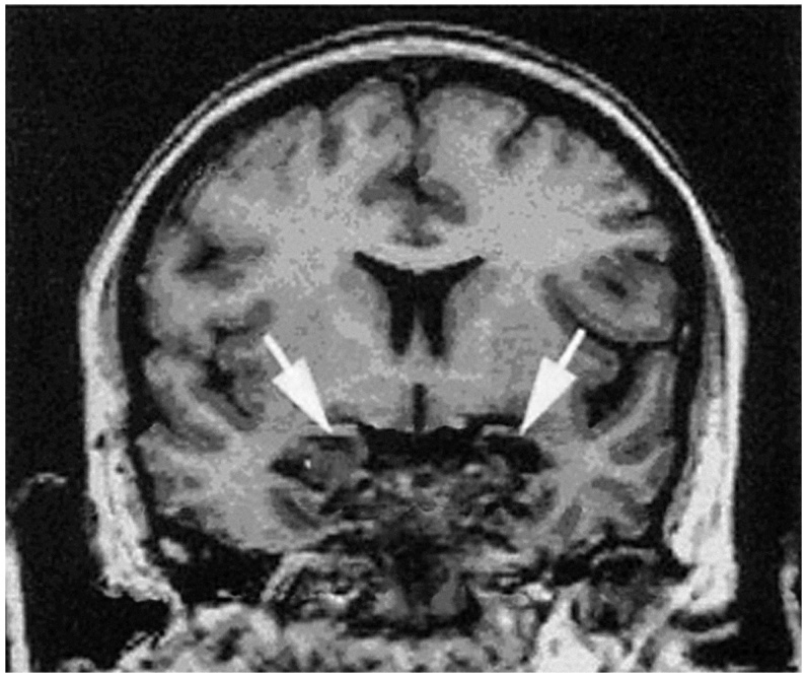


Defining emotions: 2 approaches

2. Classify *dimensions of emotion*
   - Describe emotions as reactions to events where e*ach emotion is a continuous state*
     - e.g. a little happy if you win a $5 raffle, but more happy if you win $500,000.
   - 1. Characterization based on 2 continuous variables (Osgood):
     - -Valence (pleasant-unpleasant; good-bad)
     - -Arousal (intensity of the emotion; low-high)
   - 2. Characterization based on actions and goals that motivate person to *approach/ engage* or *withdraw* (Davidson)

International Affective Picture System

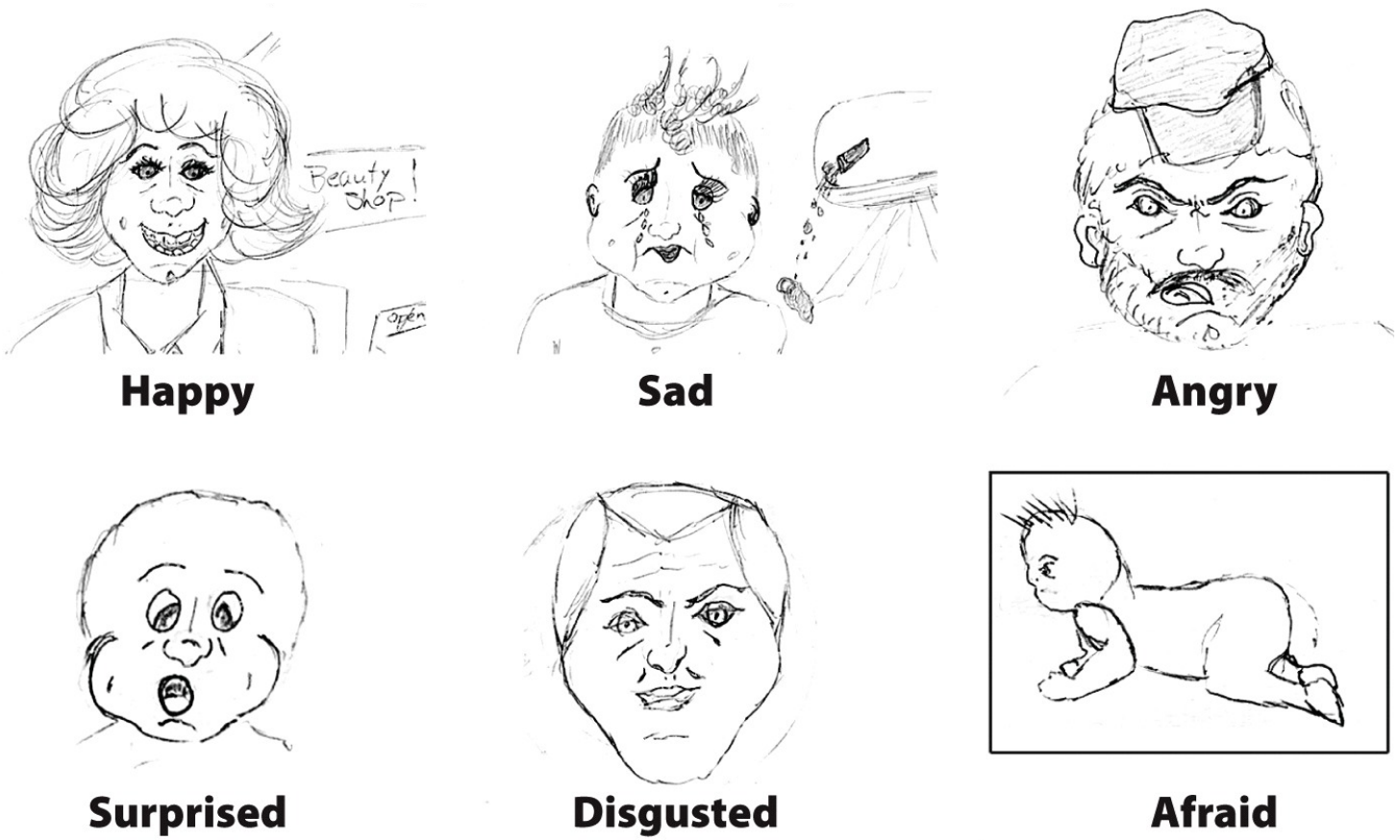
Woman who does not fear



De Martino B, Camerer CF, Adolphs R (2010) Amygdala damage eliminates money loss aversion. *PNAS* 107(8):3788-92.

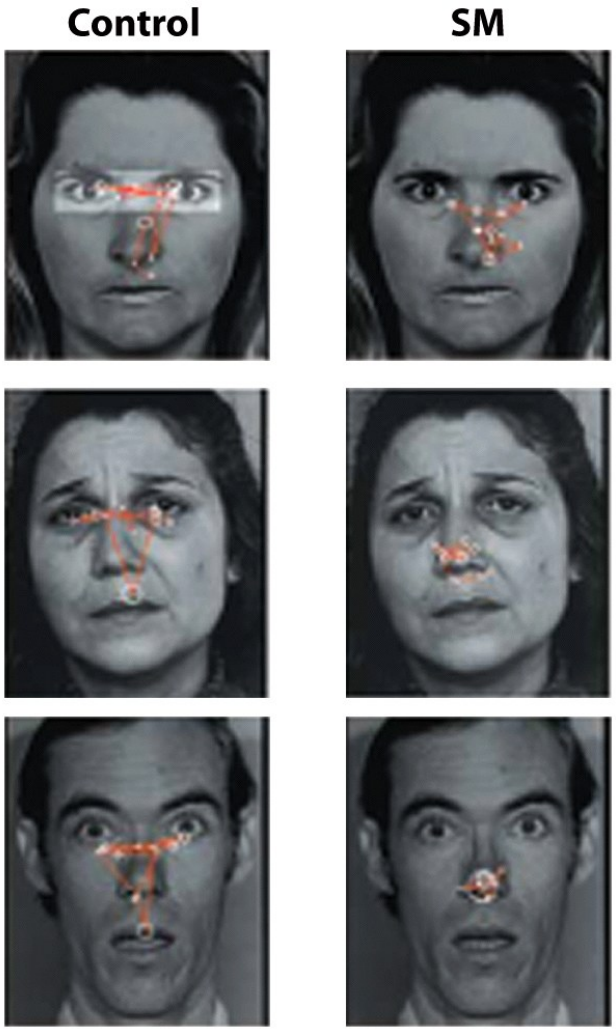
- S.M. 38 yrs old (in 2005)
- A rare genetic disorder: Urbach-Wiethe disease
- lesion of all nuclei of amygdala bilaterally; most all other subcortical structures intact.
- Normal perception, memory, language, reasoning

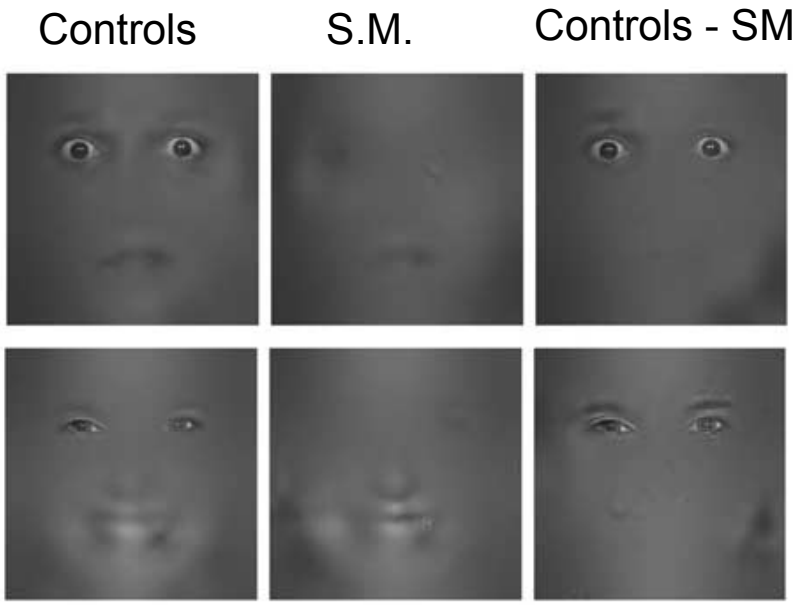
SM: deficit in generating fearful expressions



Adolphs et. al. (1995) Fear and the Human Amygdala. *The Journal of Neuroscience*, 15(9): 5878–5891. © Society for Neuroscience.

- Note most impaired when asked to draw fear.
- Why?

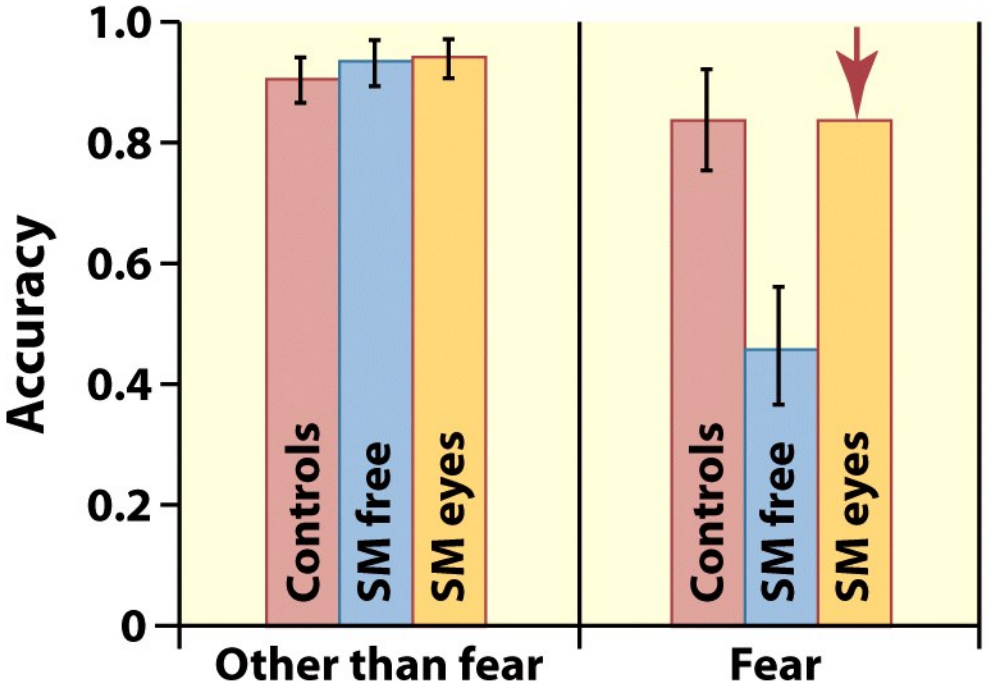


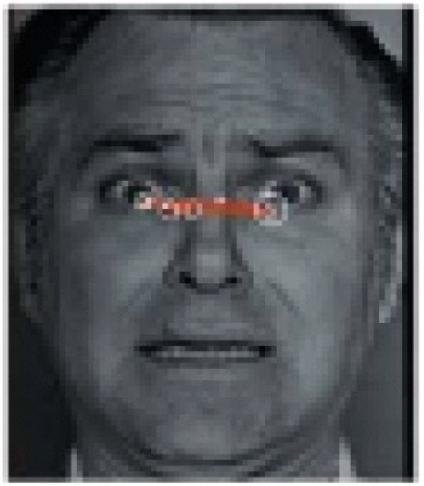


- SM does not use information from the eyes for any emotion.
- Impairs identification of fear, sadness the most (contrast with happiness, which can be inferred by the mouth).

Adolphs et al., 2005, Nature

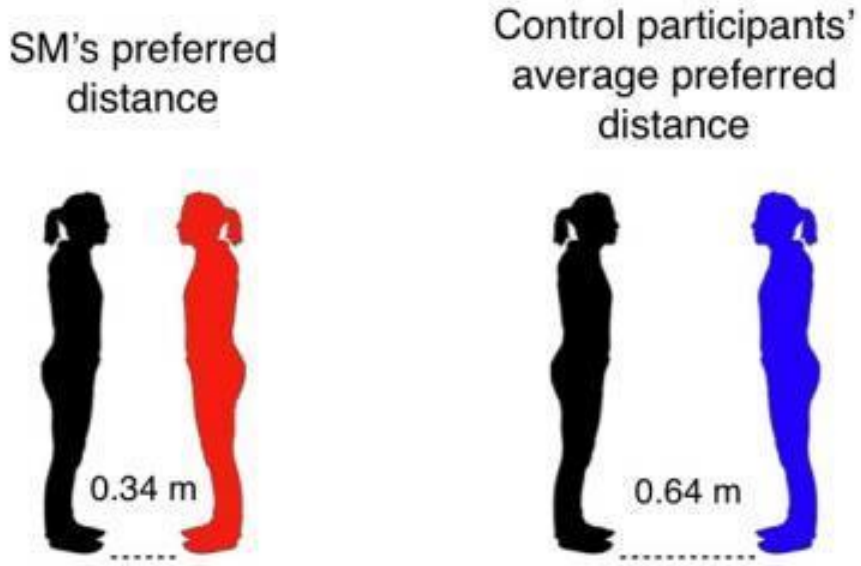
- Identification of fearful expression improves when instructed to look at the eyes.





SM and social interactions

- Difficulty judging trustworthiness of others
  - Personal space



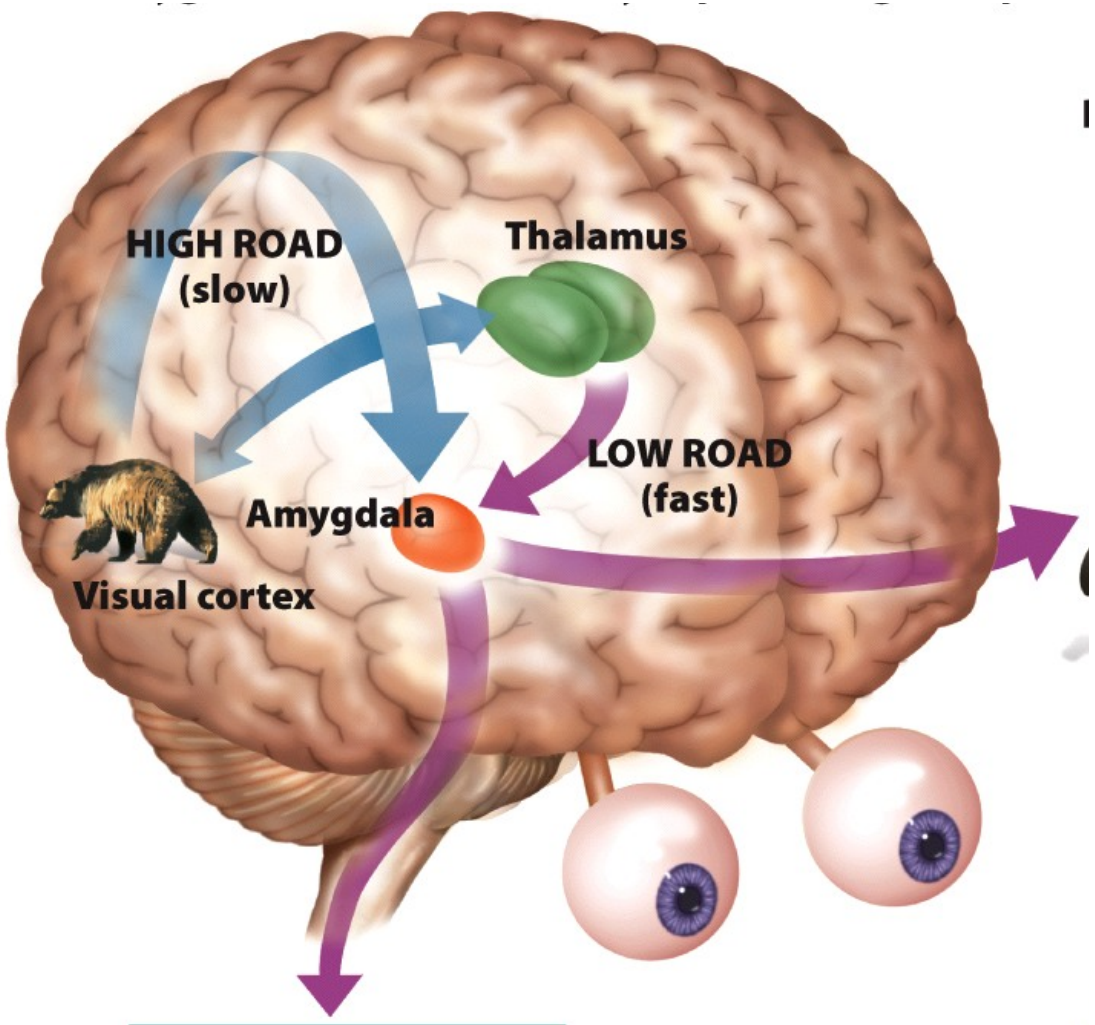
- Social behavior
  - Overly trusting
  - Overly friendly

Nature Neuroscience, 2009; DOI: 10.1038/nn.2381
Personal space regulation by the human amygdala.
Daniel P Kennedy1, Jan Gläscher1, J Michael Tyszka2 & Ralph Adolphs1,2

Amygdala: multiple pathways

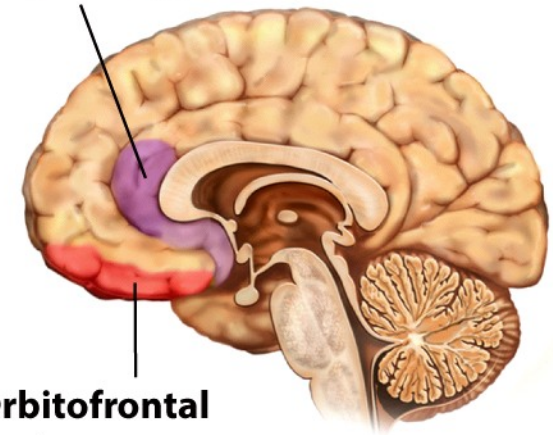
Information can reach amygdala through fast (but coarser) thalamic route as well as slower (more detailed) cortical route.

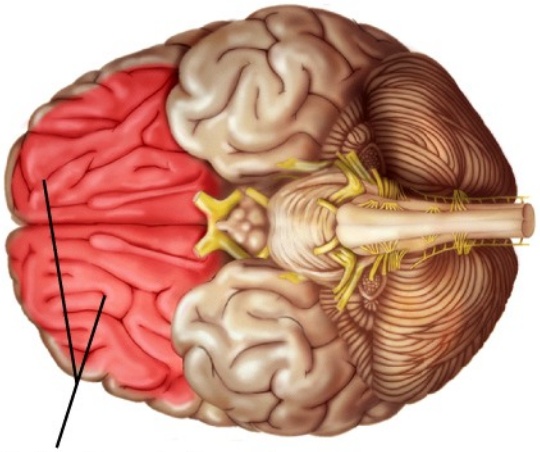
May be related to implicit and explicit emotional learning.

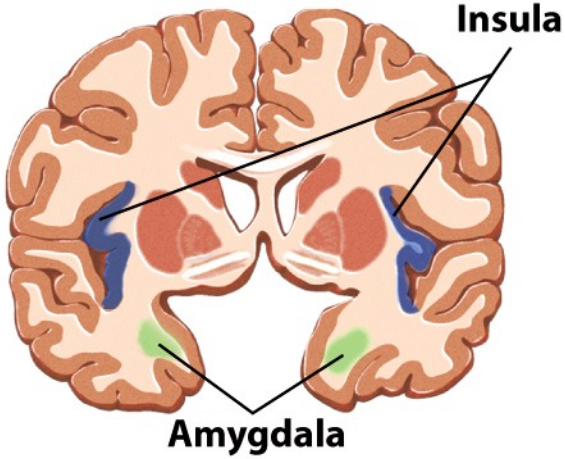


Specific brain regions for specific emotions

Disgust



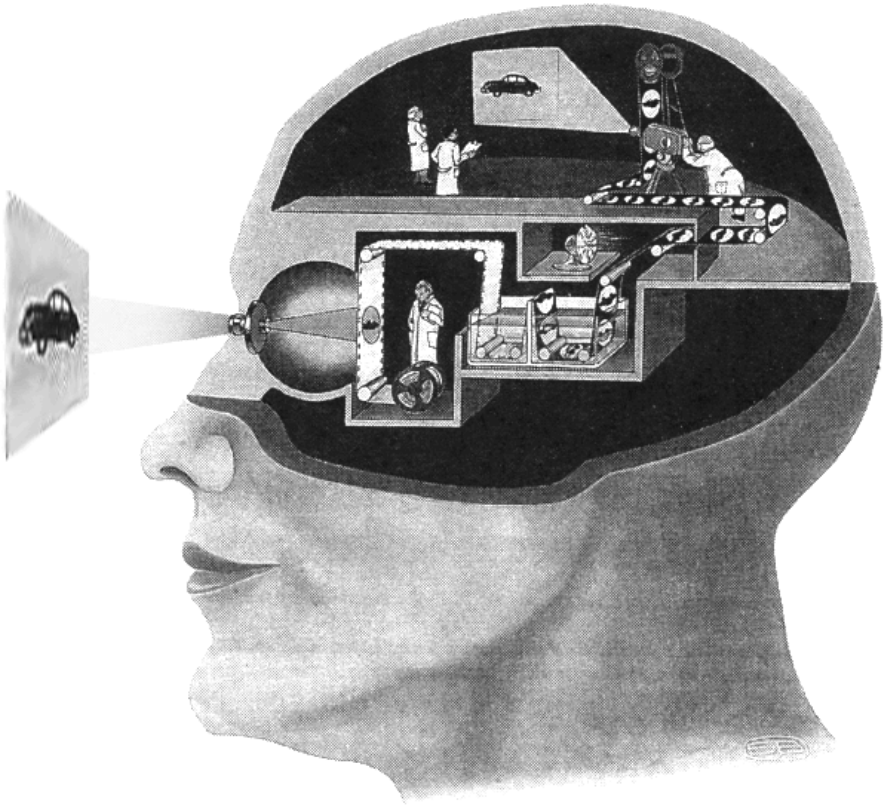


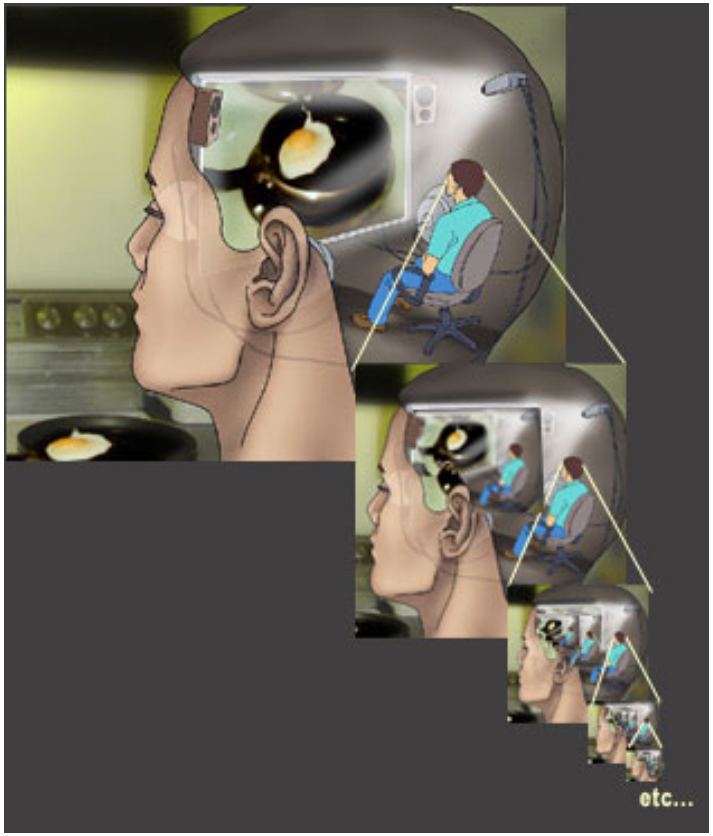


Anger

Fear

Potential issues with idea of central executive

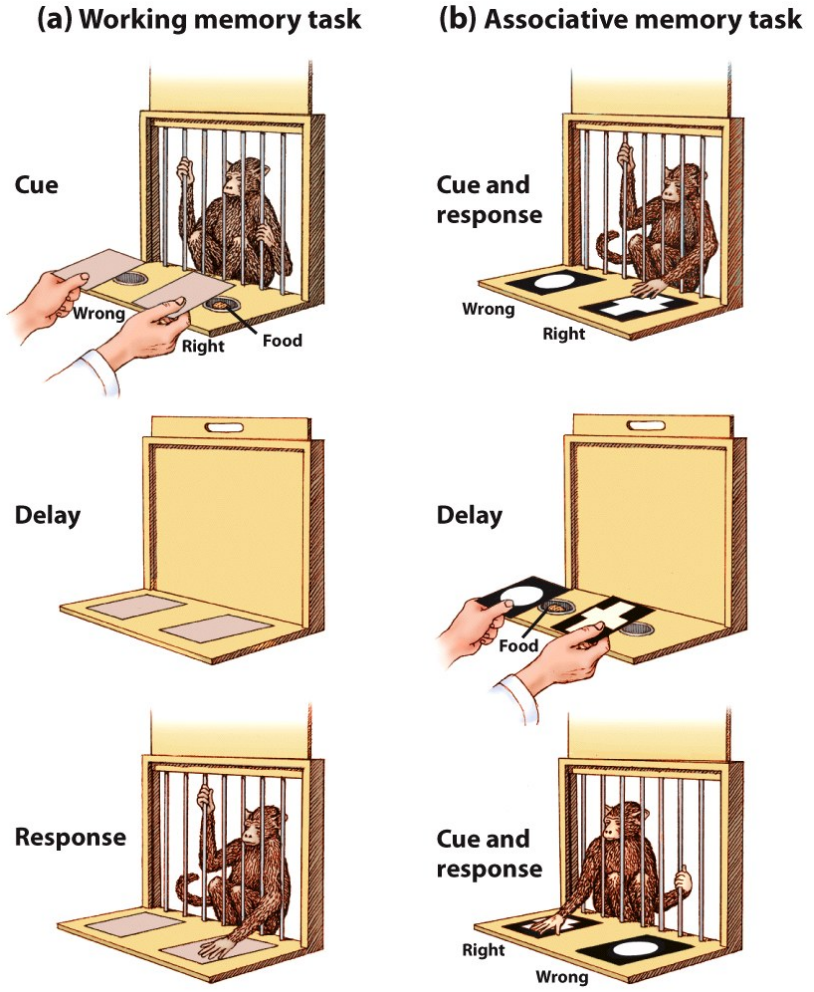




- Who controls cognitive control? An infinite regress problem
- Toward a more nuanced view of cognitive control...

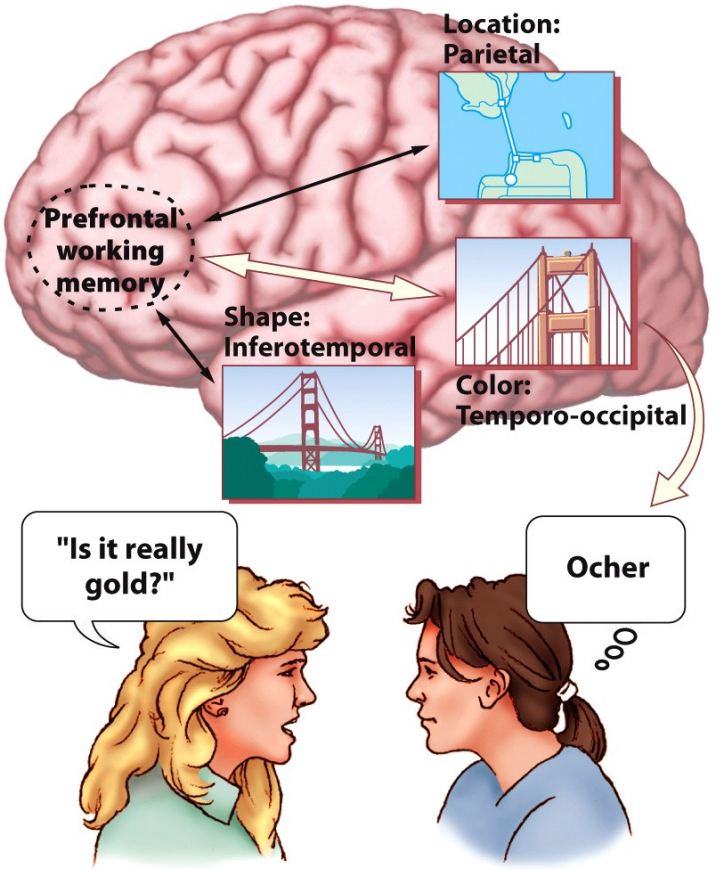
Lateral prefrontal cortex and working memory

- Delayed-response task
  - WM task:
    - Monkeys with dorsolateral prefrontal lesions (Brodmann's areas 46,9) impaired at WM task.
    - "out of sight, out of mind"
- Associative memory task
  - Long-term memory and cue recognition:
    - Prefrontal lesion monkeys ok
    - Monkeys with hippocampal lesions had trouble with similar task.



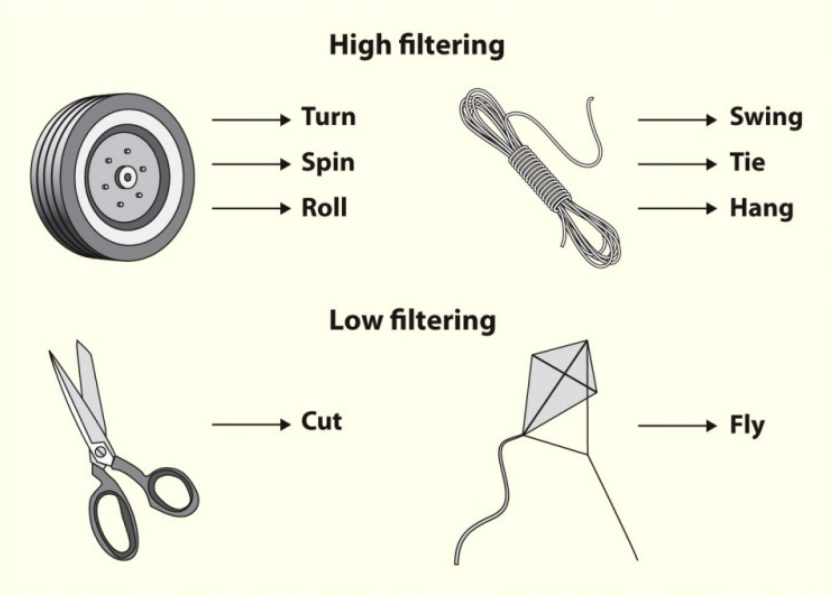
Prefrontal cortex and information selection

- Dynamic filtering hypothesis
  - PFC *selects* and maintains task-relevant information in working memory
  - *Inhibits* task-irrelevant information
  - Works with attention to modulate processing in relevant sensory areas.



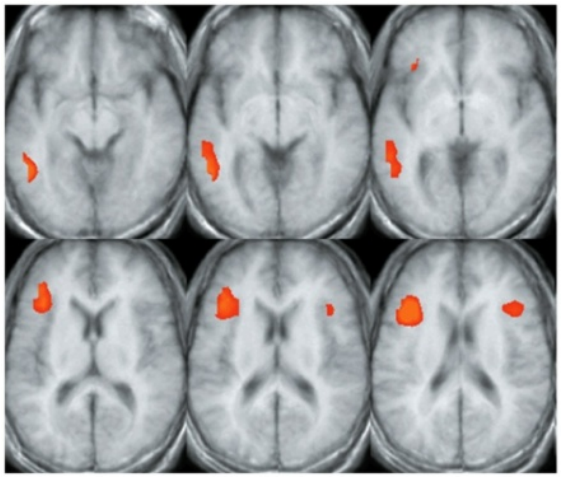
Evidence for dynamic filtering: selection

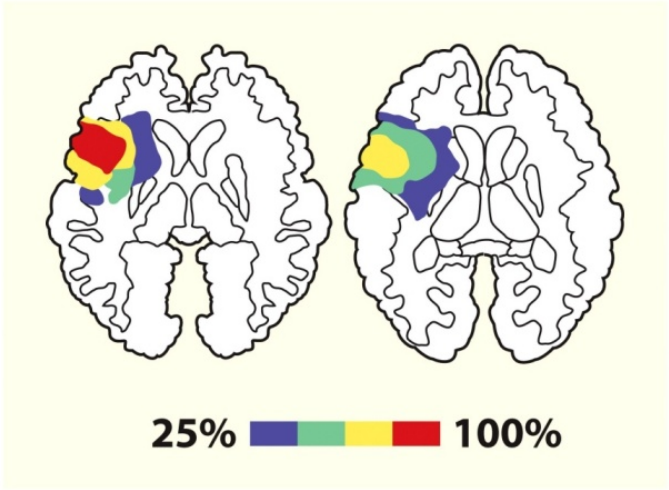
- High filtering
  - Select one of many responses
  - Lots of competition
- Low filtering
  - Little competition



Evidence for Dynamic Filtering: selection

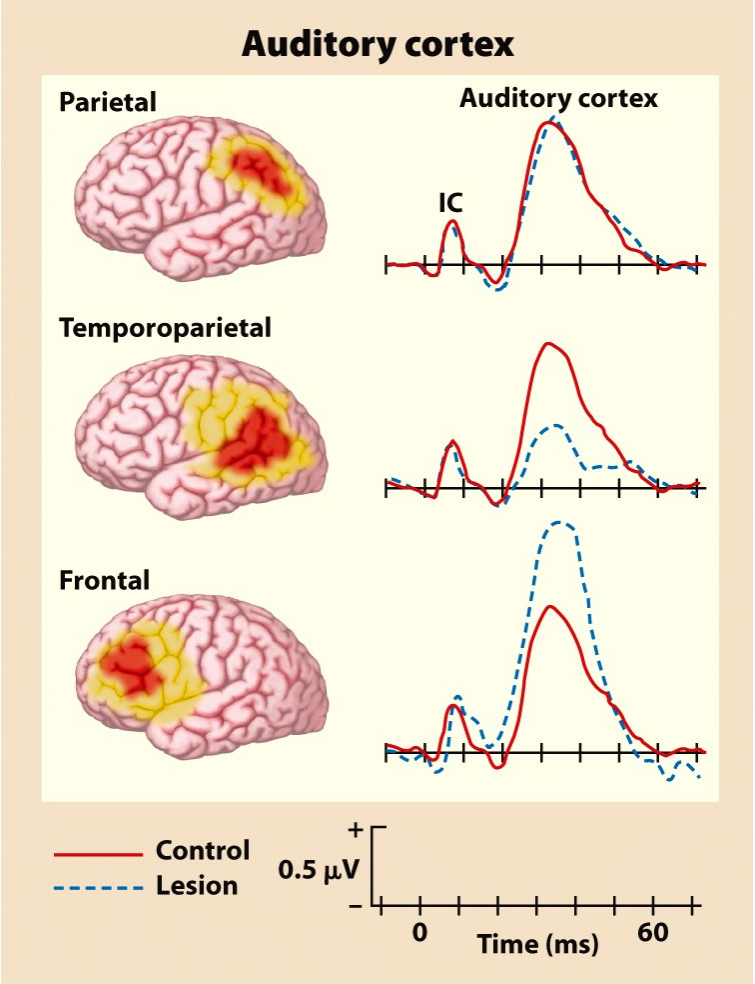
- High compared to low filtering conditions.
  - Prefrontal cortex and temporal lobe (semantic storage) more activated in fMRI.
  - Prefrontal patients failed to choose any response.
    - Not problem with semantics.
    - Not an erroneous choice.



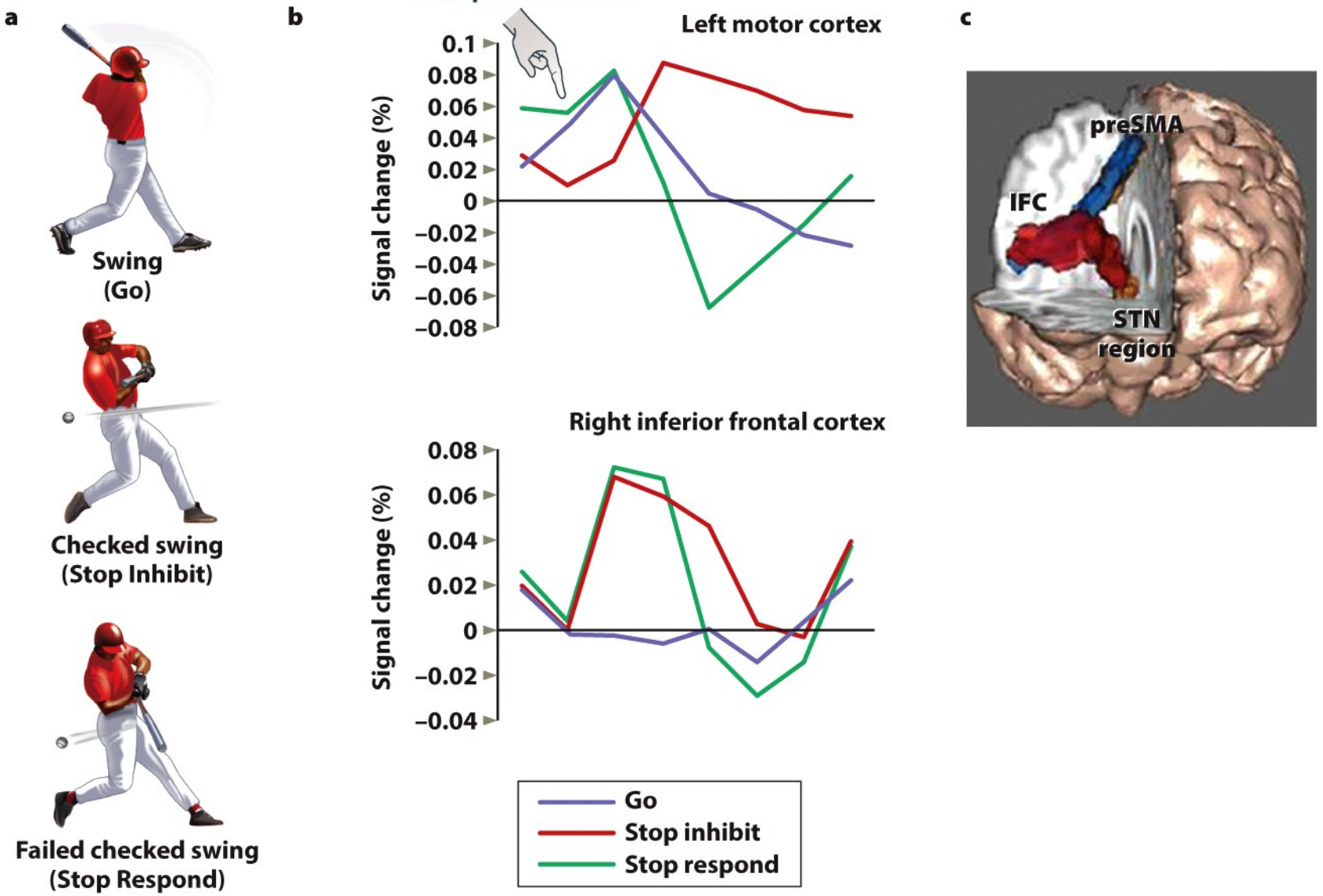


Inhibition

- ‘Ignore the auditory clicks’
- Frontal lobe patients fail to inhibit irrelevant sensory stimuli



Role of the right inferior prefrontal gyrus in inhibitory control



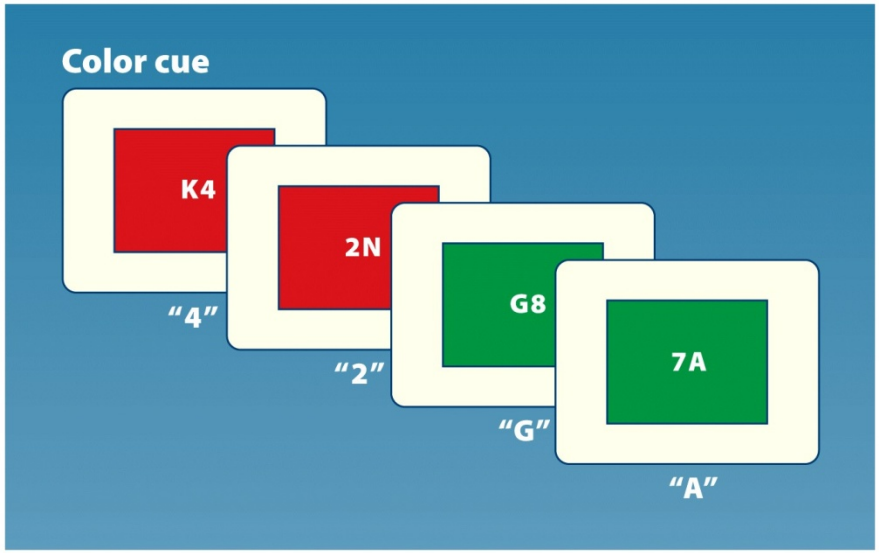
Goal oriented behavior: Wisconsin Card Sorting Task

- Sort cards according to a rule.
- Subject must "discover" rule by trial and error.
- Rule may change at any time.
- Frontal lobe patients:
  - Perseverate (apply old rule after new rule has been instantiated).
    - Trouble task-switching
  - Have difficulty keeping track of previous outcomes.
    - Selection or inhibition based on temporal order

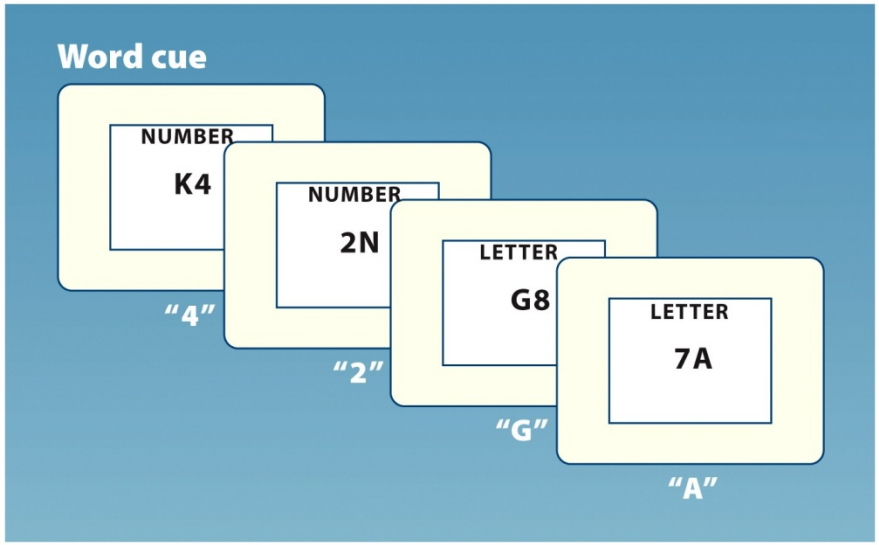
Task-switching

- Sub-goals need to be adjusted with task demands.
  - Color cue requires reference back to memory.
  - Word cue does not require memory for current task goal.

Trial # 3: RT_{switch}



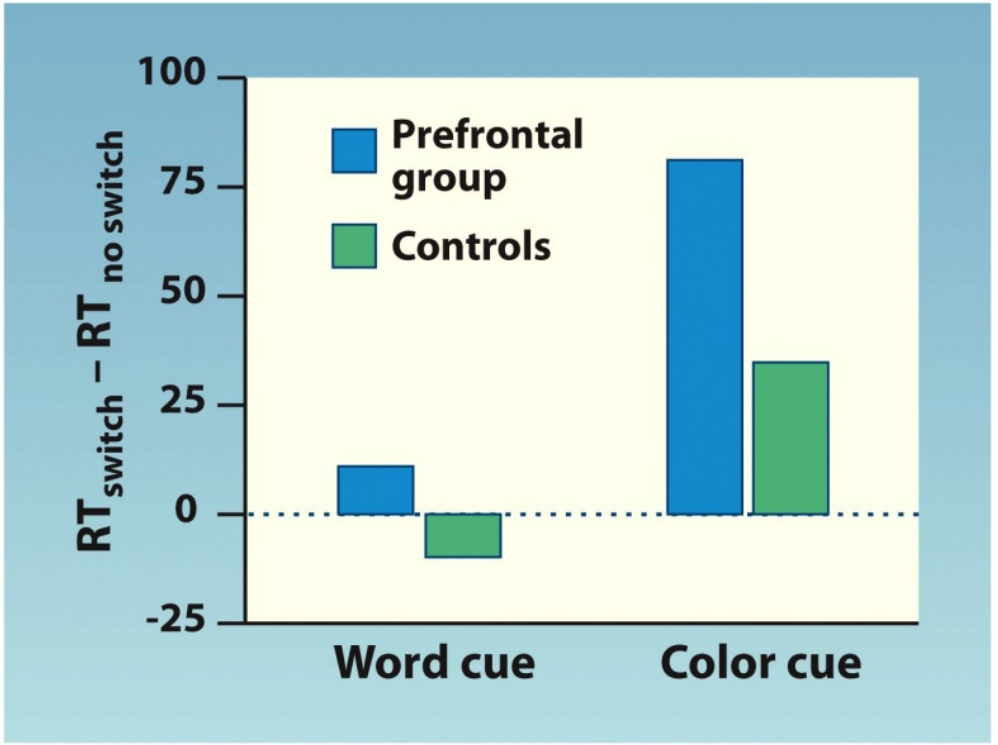
Trial # 2 & 4: $Rt_{no\text{-}switch}$



Red: number
Green: letter

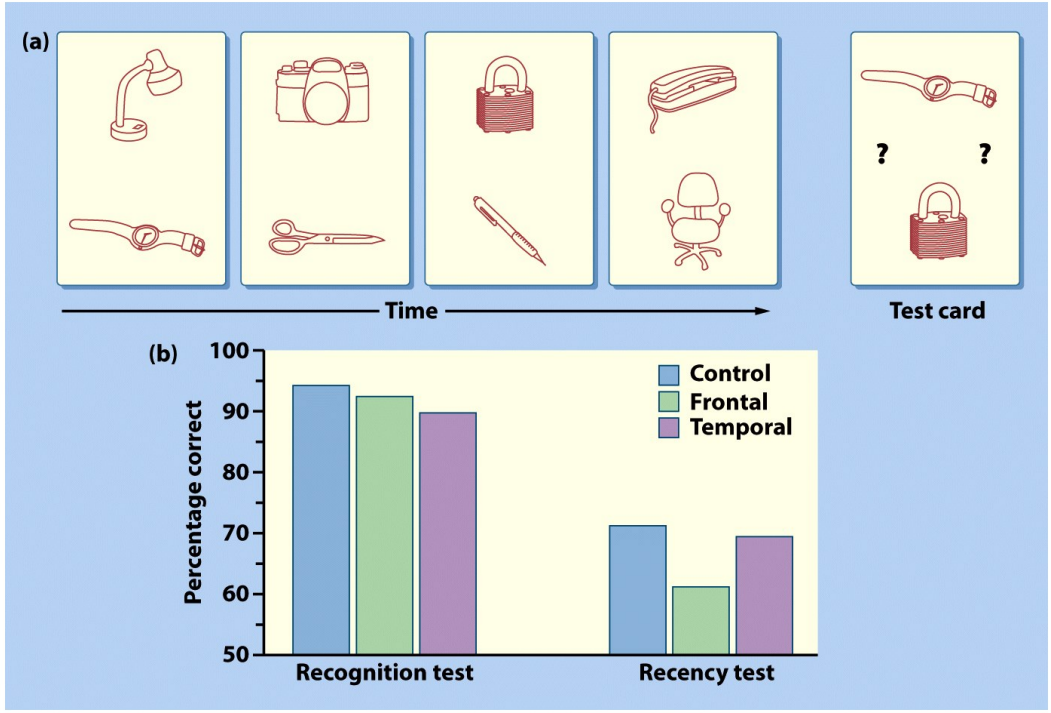
Task-switching

- *Switching cost:* slower response associated with trials where goal changes.
- Prefrontal patients worst with color cue
  - When goal needs to be retrieved from long-term memory and brought into working memory.



Prefrontal cortex and information selection over time

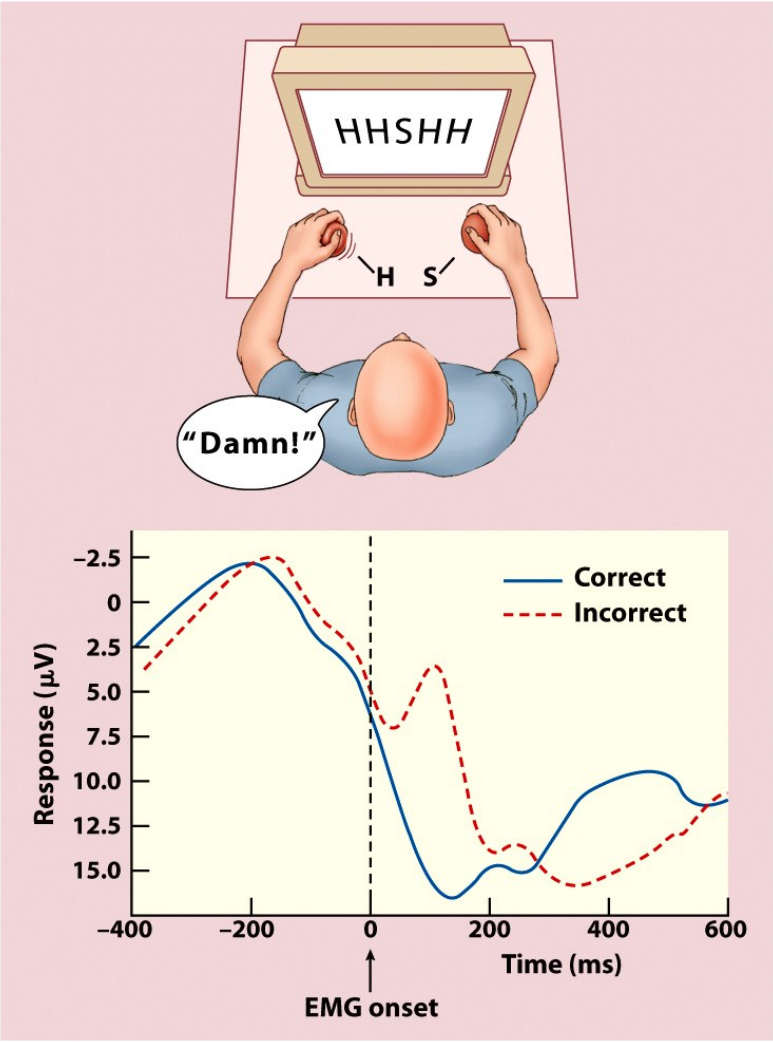
- Temporal structure of memory
  - Inability to keep track of the order in which things happened or should happen.
- Source memory
  - Where a specific fact was learned.



Recognition test –
"Was this one of the studied items?"

Recency test –
"Which one came most recently?"

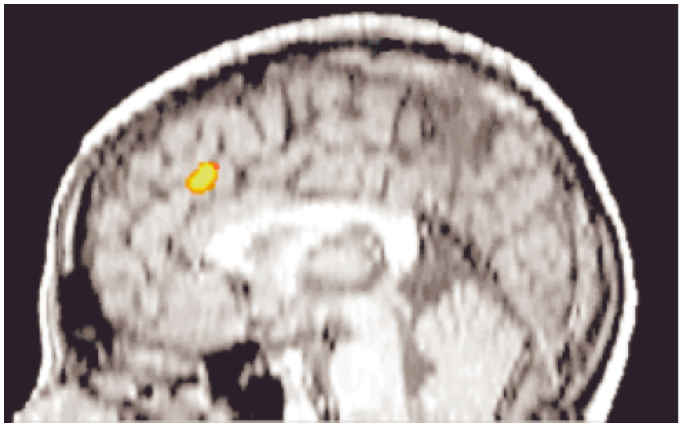
Error monitoring

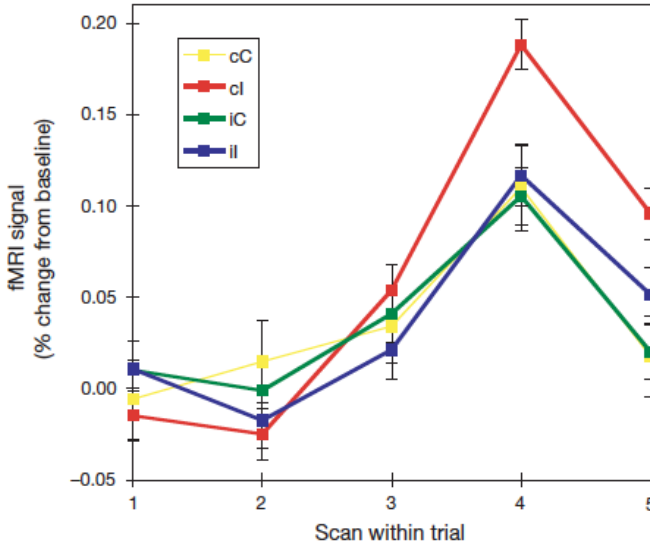


- Subjects hit one button for S another for H.
- Task is harder when distracting letter flank.
- ERP scalp response (Error-related negativity, ERN) is greater when subjects give incorrect response.
- ERN may originate from ACC within MFC

Conflict monitoring: Modified version of task uses arrows instead as flankers with fMRI

- Compatible trials:
- >>>>>> > >>>>>>>>>>
- Incompatible trials:
- <><><> < ><><><>
- Highest conflict trials will be ones in which compatible precede incompatible (cI trials).
  - Highest activation during cI trials.





Suggests activation in ACC may relate to monitoring of conflict.

Botvinick et al., 1999, Nature

Language

- Sequence of signals
- Creates images
- Is meaningful
- Is hierarchical and follows rules
- Is universal

Structure of Language

Language	=	**Semantics** meaning of a word, sentence, or passage	+	**Syntax** rules that determine how words combine into sentences

Structure of Language

Phonemes: smallest unit of speech sounds

Th | uh | b | oh | y | l | ah | ee | d

Morphemes: smallest meaningful unit of language

The | boy | lie | ed

Words

The | boy | lied

Sentences

The boy lied

Word Comprehension

Lexical semantics: meaning of words

- **Lexicon:** all of the words we know
- **Semantics:** meaning of words, sentences, or passages

Word Frequency

Is it a real word?

busy

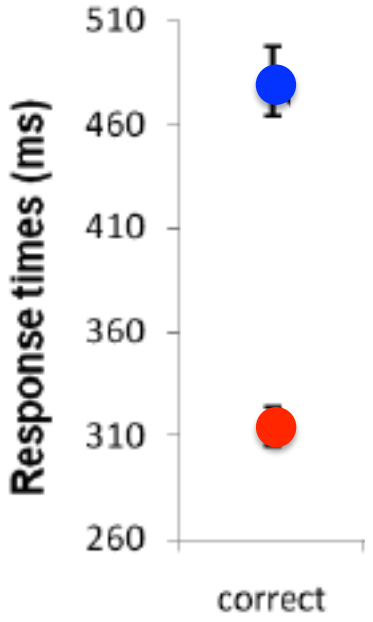
mulvow

history

chard

boovle

waltz



Lexical Decision Task

- **Word frequency effect:** we respond faster to words that occur more frequently

Word Frequency

Is it a real word?

busy

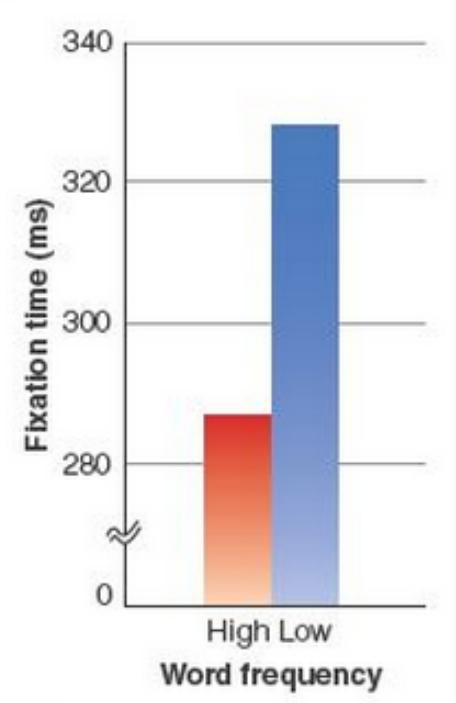
mulvow

history

chard

boovle

waltz



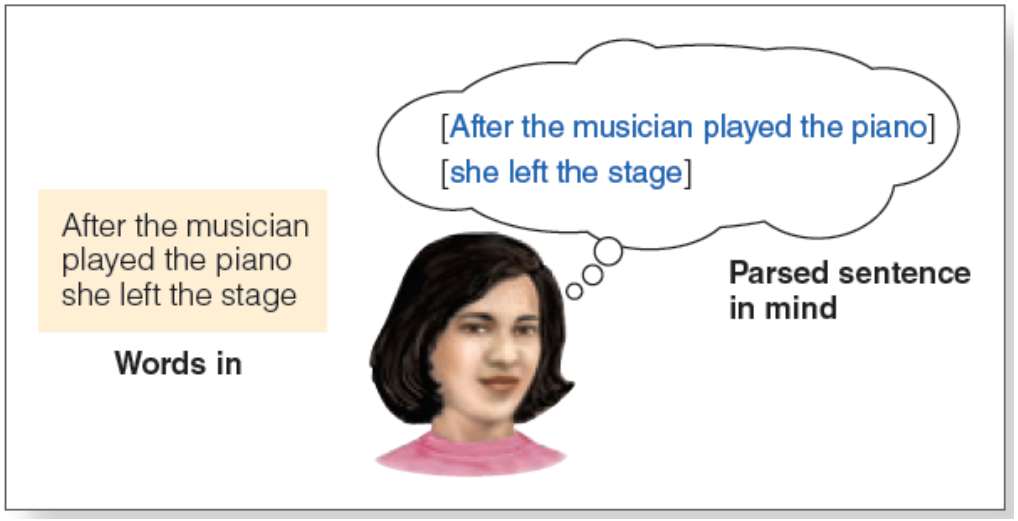
Lexical Decision Task

- **Word frequency effect:** we fixate less to words that occur more frequently

Sentence Comprehension

Phrasal semantics: meaning of sentences

- **Sentences:** strings of words in a sequence
- **Parsing:** mentally grouping the words into phrases to create meaning



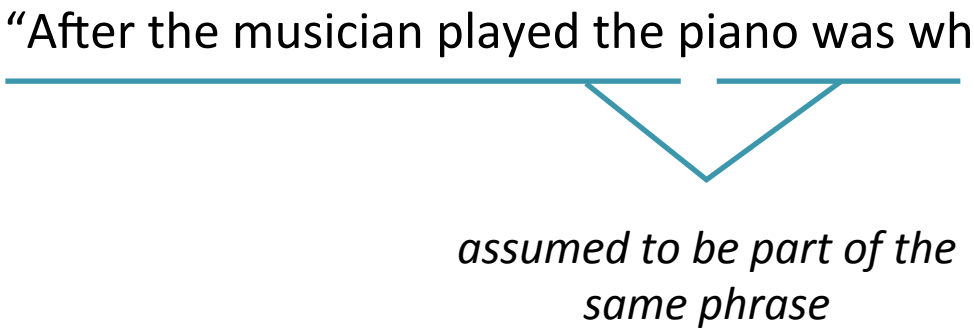
Sentence Comprehension

Phrasal Semantics = **Lexical Semantics** + **Parsing**

Garden Path Model

Garden path model of parsing: listeners use heuristics (syntax-based rules) to group words into phrases

Garden Path Model



- **Late closure:** parser assumes each new word is part of the current phrase

Constraint-Based Model

Constraint-based approach to parsing: listeners use syntax along with other information (word meaning, context, memory load) to group words into phrases

Constraint-Based Model

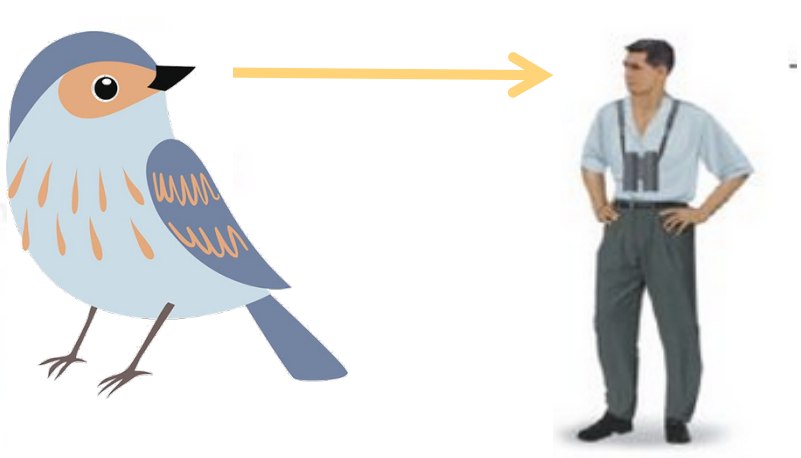
- **Word meaning** influences parsing

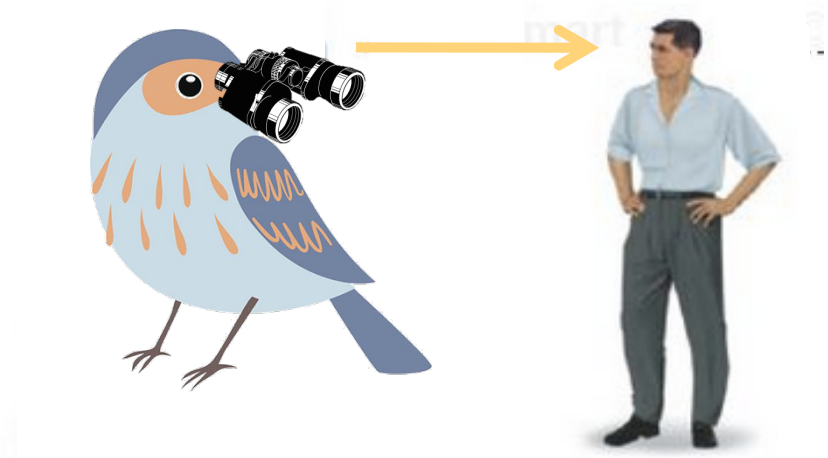
The spy saw the man with the binoculars

Constraint-Based Model

- **Word meaning** influences parsing

The BIRD saw the man with the binoculars





Constraint-Based Model

- **Story context** influences parsing

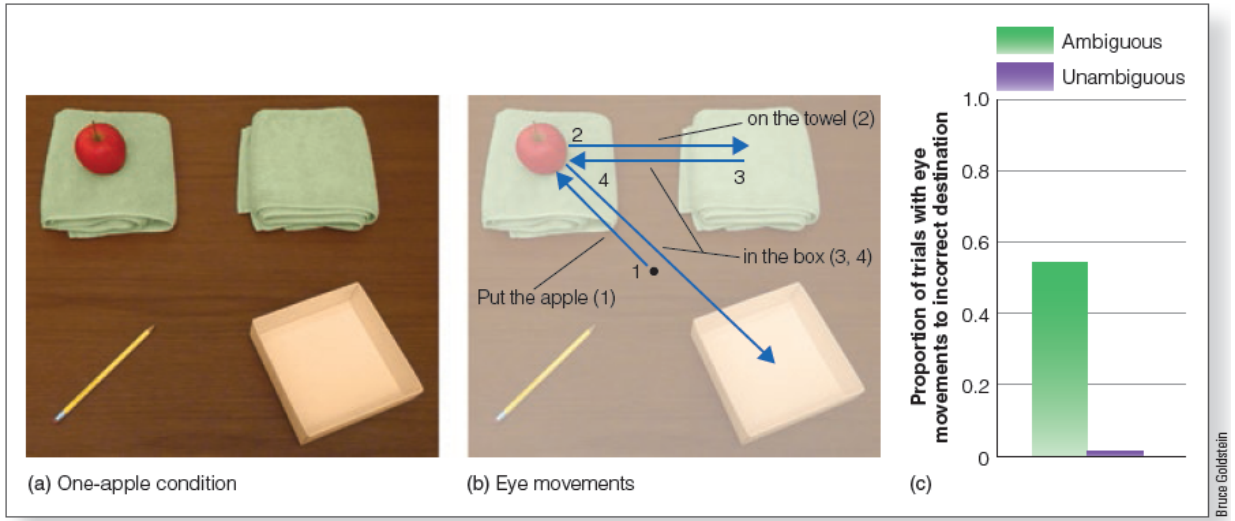
There were two jockeys who decided to race their horses. One raced his horse along the path that went past the garden. The other raced his horse along the path that went past the barn. The horse raced past the barn fell.

Constraint-Based Model

- **Scene context** influences parsing

"Place the apple that's on the towel in the box"

"Place the apple on the towel in the box"



Visual world paradigm ***(one-apple scene)***

Constraint-Based Model

- **Memory load** influences parsing

1) *The senator who spotted the reporter shouted*

2) *The senator who the reporter spotted shouted*

the main clause is the same